THE USE OF COMPUTER-BASED PLANNING TO ENHANCE THE EFFECTIVENESS AND EFFICIENCY OF SIMULATION-BASED TEAM TRAINING

by

GEORGE F. STONE III
B.S., United States Military Academy, 1980
M.S., Texas A & M University, 1989

DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy in Engineering
Department of Industrial Engineering and Management Systems
College of Engineering
University of Central Florida
Orlando, Florida

Spring Term
1996

ABSTRACT

To ensure user acceptance and success of technology-enhanced training in an era of declining budgets and scarce resources, civilian and military organizations must exploit effective and efficient planning and evaluation tools as part of simulation-based training. The purpose of this research is to validate the hypothesis that computer-based (automated) planning tools will improve training planning effectiveness and efficiency for simulation-based team training exercises. A modified pretest-posttest control group experimental design was used to determine the effectiveness and efficiency of a computer-based training planning model.

Performance measures, as well as, cognitive mapping and clustering techniques aided the assessment of the automated training planning tool. The treatment group of 27 two-person teams used a computer-based planning tool to develop a plan for conducting simulation-based training, while a control group of 25 two-person teams used current manual planning methods. Both groups then executed their respective training plans in a constructive simulation program called Janus.

Results indicate that the group which used the computer-based planning tool had a significantly better mental model of the training planning process than the control group. Based on statistical tests comparing relevant performance measures, the study concludes that a computer-based planning tool has the potential to enhance the effectiveness and efficiency of simulation-based team training.

ACKNOWLEDGMENTS

I would like to acknowledge those who helped me through inquiry and guidance on this study and the doctoral process. I am indebted to everyone from my supportive wife to an avid book reader I met on the plane to Dallas (he recommended and sent me an excellent book for Ph.D. students, Writing the Doctoral Dissertation by Davis and Parker (1979)). My chairman, Dr. James Ragusa, my committee members, Drs. Mansooreh Mollaghasemi, Kay Stanney, Avelino Gonzalez, Peter Kincaid and faculty at UCF, Drs. Gary Orwig, Kent Williams and Linda Malone provided guidance and advice to help me finish. My military and academic mentors at West Point, Colonel James Kays, Lieutenant Colonels Michael McGinnis and James Armstrong encouraged me to embark and complete this venture. Also, I thank Mr. Michael Bauman, the TRADOC Analysis Center Director, who supported my initial work with his insight and resources.

For the TREDS program, I received inspiration and encouragement at STRICOM from Colonel James Shiflett, Dr. Mona Crissey, and Colonel (ret.) Bob White. The able-minded and skilled programmers and managers in the program's software development, Jeff Abbott, George Dahm, Chuck Smith, Terri Walker-Spoonhour, Major Curt Carver, and Captain Joe Adams were instrumental in transforming the TREDS concept into a working prototype in time to conduct the experiments. Last, but not least, my heartfelt thanks to the cadets, soldiers, and officers (like Major Mark Tillman out there in the

"mud") who participated without complaint in the experiment in superb fashion. You truly deserve the best computers automation can provide.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Overview of Simulation-Based Training Tools

Aided by the acceleration of computational and database processing power, simulations are enhancing conventional training programs. As a result of recent research focusing on training, Bouwens, Jones, and Pierce (1994) conclude that growth continues in the number of opportunities for skill and task training in simulation-based environments. Simulations often involve several persons cooperating as a team to fulfill training objectives and tasks.

With the advent of simulation-based training technologies for increasing training preparedness, industry and academia strive to assess the training enhancement offered by computers (Schank, 1994). Improving productivity with technology continues to evolve as a potential aspect of everyone's future (George, Malcolm, & Jeffers, 1993). Consequently, computer-based simulations play an important role in civilian and military training for normal, emergency and life-threatening activities. Examples are simulation training for pilot/astronaut planned and contingency situations, nuclear power plant normal and emergency operations and military combat.

Using existing manual planning methods, simulation operators often assist those responsible for training in translating training requirements into executable training

exercises. Trainees seldom understand how their training requirements and plans are developed nor do they consider the need for simulation resource coordination. Poor planning and coordination often results in a time-constrained adjustment of training causing negative impact on the use of the simulation and the team's training proficiency.

An extensive review of the literature has not identified any computer-based tools being used for simulation-based training planning. The reason that such a tool may be nonexistent is that training research development efforts seem to have concentrated on the simulations instead of the entire training planning process. Even though the users can articulate training goals and objectives well, the linkages between the organization's training goals and simulation-based training outcomes must be well-defined (Keiser & Seeler, 1987). The integration of the remaining elements of automation, training, planning and evaluation will achieve an effective and efficient system for the training planning process.

Need for the Study

Training personnel continually seek ways to improve and maintain training proficiency of the organizational members and teams/crews. Frequently, the actual training event is difficult to replicate unless that event is realistically portrayed through simulation (Spitzer, 1993). Simulation-based training must be conducted formally to ensure the trainees do not adopt incorrect behaviors which may cause ill-fated consequences (Noomahan, 1993).

To enhance understanding of the training planning process, the trainer must quickly become familiar with organization procedures, practices, and regulations for training. Using the appropriate references and documents, the trainer must prepare a well-defined and organized training plan to utilize simulation resources. Training planning staffs often react quickly to events, while being held accountable for ensuring well-planned and executed training exercises. The trainer's understanding of the simulation-based training planning exercise is critical, but is dependent on experience and learning. For current and future training needs, a delay in training planning skill acquisition is often unacceptable.

The requirement to reduce costs is relevant in terms of funds and time. The reduction of training budgets must be aligned with increased computer power. Generating training scenarios usually requires hours of manual planning and other paper-intensive activities. Insufficient planning causes poorly executed training and wastes one of an organization's limited and valuable resources— training time. To prevent wasted resources, training program developers must align the goals of organizational training requirements with the simulation-based training process.

A trainer needs to have a planning tool which automates the training planning process to develop training which results in explicit feedback and linkages to future planned exercises. For a computer-based tool to assist users, it must replicate a process and reduce many routine and non-judgmental tasks. Schneiderman (1992) insists that users can "avoid the annoyance of handling routine, tedious, and error-prone tasks, and

can concentrate on critical decisions, planning, and coping with unexpected situations" (p. 83). Schneiderman also believes that computers should track large amounts of data and information using preset patterns and procedures. As a result, planners have more time and energy to make decisions, plan and react to crises (Schneiderman, 1992).

There is a need to improve the effectiveness and efficiency for team training plan preparation for simulation-based training. To ensure user acceptance and success of simulation-based training in an era of declining budgets and scarce resources, civilian and military organizations must improve the effectiveness and efficiency of training planning. One of the primary drawbacks hindering the development of a tool to satisfy those training planning requirements has been the lack of computer programs to automate tasks and activities. This study will provide the structure of a process to examine these issues for augmenting future training planning with capabilities for handling the complex requirements encompassing simulation-based training.

In summary, there is a need to investigate the value of automated planning tools for simulation-based training. These tools are important in that they have the potential to:

1. improve and maintain training proficiency through effective planning,

2. enhance understanding of the training planning process to accommodate large turnovers in training personnel,

3. reduce costs to meet shrinking training budgets for simulations and support personnel, and

4. automate the training planning process to achieve better training results and build training outcome linkages to future planned exercises.

Statement of the Problem

Simulation training plan development is not being done as effectively and as efficiently as possible due to a lack of understanding of the training plan development process and the unavailability of computer-based tools. Planning for training requires knowledge and experience in the training planning development process. For the most part, manual methods (non-computer based) are still being used to develop training plans for classroom, simulator, and insitu training environments. Improvements are critically needed in training planning for simulations in order to enhance personnel training through effective training plans, and efficient time, manpower and money utilization.

Major questions related to this problem are:

1. What contributions do computer-based planning tools offer to simulation-based team training?

2. What is the best method of computer-based training planning?

3. What are some improved quantitative measures of training effectiveness required to assess training?

The first question *(What contributions do computer-based planning tools offer to simulation-based team training)* is the primary focus of this study. Some researchers and practitioners believe that computer-based tools contribute to productivity, but there are few tests which corroborate this point. Very few authors provide empirical evidence or

logical methods which support the technology beyond hearsay or subjective assessment (Keiser & Seeler, 1987).

According to Eberts (1994), "the computer user perceives, stores and retrieves information" from memory, then synthesizes that information to conduct decisions for problem-solving and future action (p. 139). Measured in terms of the overall contribution to the organization's training proficiency of teams and individuals, the success of a simulation-based training exercise relies upon consistent and thorough planning. The training planning process must examine the development of scenarios and conditions specific to simulation-based training. There are existing manual methods which have become obsolete due to the enormous detail and planning involved. Therefore, computers can assist in routine processes, as well as, the guidance of the users through a logical sequential operation for training plan development.

Hypothesis: The use of a computer-based planning tool instead of current manual methods will improve the training plan development process for a constructive simulation exercise. Within this environment:

1. Computer-based planning tools will enhance the mental model of the training plan development process.

2. More effective training plans will be created and results achieved with computer-based planning tools.

3. Simulation-based training planning will be accomplished more efficiently using computer-based tools.

In order for the reader to understand some of the words and phrases used throughout the study, definitions are now presented. In addition, Appendix A includes a list of the abbreviations and acronyms used in this study.

Definition of Terms

Computer-based tool. A device or system based on digital computer technologies.

Computer. "A programmable (changeable) device that accepts input, manipulates data and outputs data in some form" (Shedroff, Hutto, & Fromm, 1993, p. 134).

Constructive simulation. A simulation with a game component which involves human interaction and computer models for replicating realistic scenarios.

Distributed interactive simulation (DIS). A simulation architecture which allows large numbers of simulated systems, both manned and unmanned, at different locations to interact at the same time to accomplish a common training mission via communication networks (Kazarian & Schultz, 1994).

Effectiveness. "The extent to which the structure leads to improved performance, makes a difficult task easier, or enables accomplishing a task that could not otherwise be accomplished." (Rouse, 1991, p. 23).

Efficiency. The ratio of input resources versus output results.

Free recall. The depiction of steps or components of a process using textual or pictorial representation.

Game. "A structured activity in which two or more participants compete within constraints of rules to achieve an objective" (Keiser & Seeler, 1987, p. 460).

Manual tool. Any device which does not use electronic means of calculation, organization or data manipulation.

Mental model. Arrangement of information into structured patterns which allow versatile storage and retrieval of information in terms of features related to situations, entities and environmental conditions (Tannenbaum, Cannon-Bowers, Salas, & Mathieu, 1993).

Position memory. The restatement of items from memory recall which were presented in categorical lists.

Scenario. Details of the subject of the simulation, outlined with the objectives and game rules for the participants (Keiser & Seeler, 1987).

Simulation. "An operational model, using selected components, of a real or hypothetical process, mechanism, or system" (Keiser & Seeler, 1987, p. 460); uses only mathematical relationships to simulate actions and behaviors.

Simulator. "A simulation with no game component -- the use of computer-based simulators to replace training on actual equipment" (Keiser & Seeler, 1987, p. 461); combines both mathematical and physical relationships for behavioral characteristics.

Structured questionnaire. "A questionnaire which includes fixed items, fixed response categories and fixed sequencing of items." (Sproull, 1995, p. 387).

Subject matter expert (SME). An individual who is considered very knowledgeable in his/her field of study or a specific area.

Team. "A distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/objective/mission, who have each been assigned specific roles or functions to perform, and who have a limited life span of membership" (Salas, Dickinson, Converse, & Tannenbaum, 1992, p. 1297).

Methodology

The experimental design used in the study was the pretest-posttest control group design articulated by Gibson, Ivancevich, and Donnelly (1994). This design is best where gain or change in behavior is the desired dependent variable. For this study, the change of the user's mental model of the training planning process is one of the dependent variables. The other dependent variables are Task Load Index (TLX) scores, performance times, quality ratings and simulation measures of effectiveness (MOE). The independent variable was the use or nonuse of computer-based planning tools to support simulation-based training.

This study was conducted at the University of Central Florida, Fort Knox, Kentucky, and Fort Hood, Texas, from May to July 1995. The sample population

consisted of officers, noncommissioned officers and cadets who were involved in the training planning process. Officers normally have the education for training planning, while the noncommissioned officers have the experience in execution and conduct of training. Cadets were used in the pilot test in order to have a test population which could provide naive expertise to the evaluation of the experimental design and instruments. All volunteers were randomly assigned to either manual or automated two-person planning teams.

Prior to the primary study data collection, a pilot test was conducted in Orlando with University of Central Florida (UCF) Army Reserve Officers Training Corps (AROTC) cadets. The pilot group assisted in identifying areas of concern through a rehearsal of the experiment.

Primary study data were collected at Fort Knox, Kentucky, in May 1995, and Fort Hood, Texas, in June 1995. Two-person planning teams consisted of an officer who has the training education and a noncommissioned officer who normally has the training experience. At Fort Knox, the sample was created by forming 16 automated and 15 manual two-person planning teams from an Armor battalion. At Fort Hood, the study sample consisted of 11 automated and 10 manual two-person planning teams participating also from an Armor battalion. Training time was also allocated to teach the Janus simulation and to orient the computer-based teams on using the Training Exercise Development System (TREDS) computer-based planning tool. Analysis of the primary study data was conducted using nonparametrics statistics. The power of the

nonparametrics test by Mann-Whitney was deemed more appropriate for the post-test data, whereas the Wilcoxon signed-ranks test was used to compare the data for the pretest-posttest component of the design (Conover, 1980).

Limitations of the Study

The limitations of the study were:

1. A constructive simulation was used.

2. Test subjects were randomly selected from two military organizations versus the entire population at large.

The first limitation was that the research focused on team training using a constructive simulation. Constructive simulations have been used extensively for training teams for over ten years. Their recognition as viable training simulations is seen by the large annual funding and efforts applied to constructive simulations' development. An attempt to introduce a live or virtual simulation would have greatly increased workload, scope and data for the experiment and may have provided less added benefit to the study. The limitation of using only one type of simulation did not appear to hinder gathering informative study data.

The second limitation was that the test subjects were randomly selected from two military organizations versus the entire population at large. The study was limited to test subjects randomly selected from two military organizations since it was impractical to test the entire population. The sample population adequately represented the population.

A demographics data form (in Appendix B) was developed to verify this assumption on the representativeness of training planners in the U.S. Army.

The use of a constructive simulation and designated units for sample populations were practical limitations that did not appear to significantly alter the experimental conditions nor the results.

Assumptions

The following assumptions were made concerning the conduct of the study:

1. simulation is a valid method for executing training, and

2. experiences and training knowledge of those tested were representative of teams involved in the Army's training simulation programs.

The first assumption for this study is that simulation have already been recognized by trainers as a viable means to improve team proficiency (Kieser & Seeler, 1987). Studies have presumed that simulations do enhance team proficiency as the foundation for future research activities (Gonzalez & Ingraham, 1994; Pemberton, Classe, Bradley, & Wilson, 1994). Verbal and written assessments obtained through interviews and the post-exercise questionnaire (see form in Appendix C) later supported this assumption that simulation improved training proficiency.

The second assumption presupposes that the study's subjects represent a cross-section of the population of simulation-based training planners. The testing was organized to test 52 two-person planning teams at two military installations which have

similar missions. Since the Army rotates leaders frequently between organizations, the assumption is that the experiences and training knowledge of the groups tested represent all teams involved in the training simulation process. Consequently, continued testing should yield representative results.

Summary

The advent of simulation-based training is proving to be a mainstay for civilian and military training in normal, emergency, and life-threatening activities. Areas of application include pilot/astronaut training, nuclear power plant operations, and military combat simulation. As various disciplines assess the importance of simulation-based training, issues surface regarding the preparation and optimization of this new training mode.

The purpose of this study was to test the hypothesis that the use of a computer-based planning tool instead of current manual methods will improve the training plan development process for a team simulation-based training exercise. The application or nonapplication of computer-based planning tools was the independent variable. The methodology for this study was a modified experimental pretest-posttest control group design. Testing was planned at two research sites in Fort Knox, Kentucky, and Fort Hood, Texas, for 52 two-person planning teams. The data analyses between the independent samples were conducted using descriptive and nonparametric statistics.

Limitations of the study were that only the Janus simulation was used and that the test subjects were only from two organizations. The first assumption was the statement that simulation enables credible training execution. Secondly, the study plan assumed that the experiences and training knowledge of the subjects adequately represented those involved in military training simulations.

The original contribution of the research conducted in this study is the partial validation of benefits derived from the use of computer-based planning tools to enhance the effectiveness and efficiency of simulation-based team training. Specifically, the study assesses whether computer-based training plan development for simulation-based training:

1. provides a methodology for validating the use of computer-based planning tools to enhance the effectiveness and efficiency of simulation-based training,

2. identifies the linkage between training task requirements and simulation-based training characteristics by building a mental model of the training plan development process, and

3. assists future research efforts by providing potential measures of effectiveness and efficiency for evaluating technological advancements.

CHAPTER 2

LITERATURE REVIEW

The purpose of this study was to investigate the contributions that computer-based planning tools offer to simulation-based team training. This chapter presents the results of a literature review of relevant topics important to answering the research question and identifying training metrics. These topics are:

1. the training process,
2. training plan development,
3. computer-based training planning tools,
4. measures of training effectiveness, and
5. measures of training efficiency.

These topics will now be discussed in the same order as outlined to facilitate understanding of the entire study plan. Of primary importance in this study is the training process as it is influenced by all components of this study. Secondly, training plan development impacts on current and future training methods in both civilian and military environments. Third, the availability and flexibility of computer-based planning tools was examined and compared with manual planning methods for simulation-based

training. Finally, the remaining two areas concerned performance evaluation measures—effectiveness and efficiency.

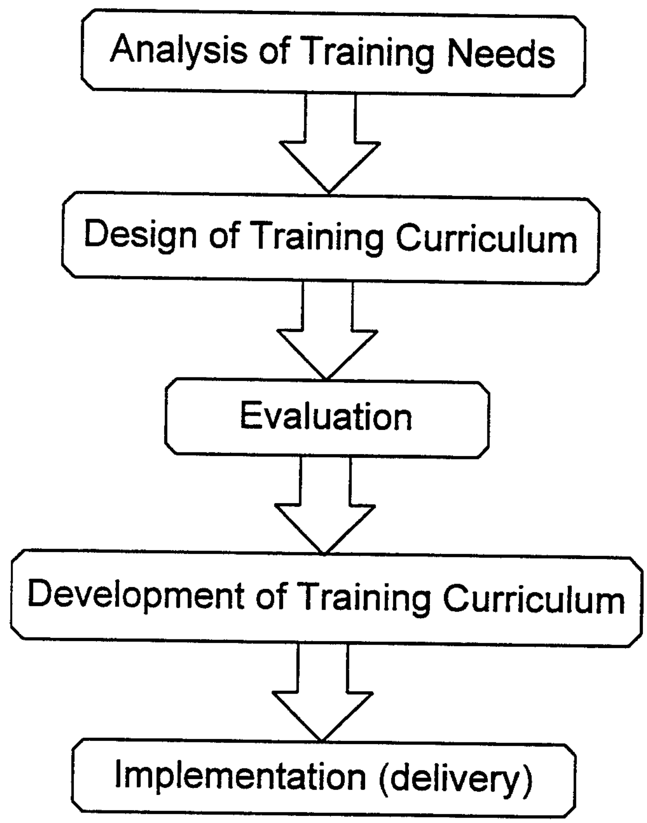
The Training Process

With recent trends toward simulation-based training, understanding the systematic training model, team versus individual training, and simulation-based training is critical. The training model is a representation of those factors and training tasks which must be accomplished to improve the proficiency of the intended training audience. Two of the most common forms of training are individual training and team training. An overview of simulations will serve to define and highlight this media for training. Simulations also include multiple and complex features which planners must consider in training plan development. The training system's goal is "to guide the development of a cognitive model" (p. 15) which will instill an accurate "representation of the tasks to be performed and the information necessary for their performance" (Williams, Reynolds, Carolan, Anglin & Shrestha, 1989, p. 15).

The Systematic Training Model

In the training process, the model which typifies those actions and procedures for training planners to follow is the systematic training model. "To be *systematic*, a training development process has to be standardized, comprehensive, internally consistent, and reliable" (Gropper & Ross, 1987, p. 196). The first representative systematic training model, the Instructional Systems Design (ISD) model, was developed during World War

II by the U.S. military to train soldiers to react to situations using behavioral psychology (Gropper & Ross, 1987). Sloman (1994) synthesizes the components of the ISD model into the five stages shown in Figure 1.



(Sloman, 1994, p. 40)

Figure 1. Systematic Training Model

To determine the training need, an analysis of the training audience's requirements forms the basis for ensuring that the appropriate training curricula is designed and developed. Training execution or delivery is the conduct of the planned training, while evaluation of the training audience provides diagnostics for the training. Sloman (1994) asserts that future training models need to "retain the best elements of the

systematic training model" and stipulates that the five ISD components must be augmented to:

1. offer the trainer a structured and disciplined framework in which to work,

2. ensure that an effective loop from evaluation is in operation, and

3. emphasize the importance of quantifiable results, even though the feasibility of this [quantifying the results] varies (p. 40).

The systematic training model has proven itself through longevity and utility. These additions promise to enhance the training model and allow a developer to build a consistent, effective and measurable training program. Organizational characteristics and training environments are also important in developing a training model. Consequently, Sloman (1994) specifies that the effective training model must also consider:

1. the need to embed training activity firmly in the organization, thus securing links to strategic objectives and permitting training to operate in a corporate context,

2. that the training function has a role in articulating training needs as well as reacting to them, and

3. that different organizations are at different stages in terms of training sophistication and different approaches may therefore be necessary (p. 40).

In addition to identifying the characteristics and environmental considerations for training, the identification of training needs in a training model must first determine whether the training will be for individuals or teams.

Individual Versus Team Training

According to Salas, Dickinson, Converse, and Tannenbaum (1992), individual team members should be allowed time to master individual skills in order to achieve more effective and efficient team training results. Individual simulation-based training often involves hands-on training with simulators, while team training incorporates a collection of individuals who coordinate and conduct their tasks to accomplish a team-centered objective. When both individual and team skills are required, the optimal mix of individual and team training must consider the amount and timing for each set of training to occur (Salas, Dickinson, Converse, & Tannenbaum, 1992).

The transition from individual to team training does not occur by the creation of the team as a set of two or more individuals. "Training for battle group team members usually progresses from simulation-based instruction on individual operator tasks, through simulation training for subteams and single-platform teams, to simulation for multiple-platform teams" (Turnage, Houser, & Hofmann, 1989, p. A-1). Team members normally apply simulation-based training to progress from individual tasks to team tasks.

Recent efforts by the U.S. Navy's Naval Air Warfare Center Training Systems Division (NAWCTSD) for enhancing training in the U.S. Navy encompasses several areas. The Navy's primary emphasis to convert training theory into techniques (Cannon-Bowers, Tannenbaum, Salas, & Converse, 1991) is evidenced by numerous applications to team training (Hall, Dwyer, Cannon-Bowers, Salas & Volpe, 1993; Tannenbaum, Cannon-Bowers, Salas, & Mathieu, 1993; Rouse, Cannon-Bowers, & Salas, 1992),

computer-based exercise preparation (Pemberton, Classe, Bradley, & Wilson, 1994), and intelligent embedded trainers (Gluckman & Willis, 1994; Cannon-Bowers, Salas, Duncan, & Halley, 1994). Each of these areas are based on the Navy's team training concepts and principles which are divided into the following levels:

1. preteam indoctrination training,
2. subteam system training,
3. system subteam training,
4. system level operational training, and
5. multiunit system operational training (Turnage, Houser, & Hofmann, 1989, p. A-1).

The five levels of team training indicate that there are several types of audiences for planners to consider when developing training. Due to the emphasis on aircrew, seaborne and submariner team training at sea, it becomes obvious why the Navy focuses most of its research in supporting team training. Since many teams may not be represented fully at sea, the simulation-based training allows for more flexibility by substituting actual team members with computer-generated forces. There is a definite need for training team responsibilities and coordination.

Team cohesion and interaction build over time. Turnage, Houser, and Hofmann (1989) view the mature team as one which can operate successfully as a single organism in dynamic, and often stressful, environments. In order to achieve such a goal as a team,

the individuals must master their skills. In this manner, industry and academia can apply simulation-based training for team development and proficiency.

Simulation-Based Training

This section examines the application of simulations, as well as, the capabilities, benefits and limitations of simulations. Often used in conjunction with learning exercises, simulations assist as problem-solving decision tools and evaluation devices (Keiser & Seeler, 1987). Using simulations, problem-solving and decision-making skills can be learned better in dynamic, complex and actualistic settings (Keiser & Seeler, 1987).

The widespread use of simulations encompasses a spectrum ranging from applications in mining engineering to virtual medical surgery. A Rand study classified simulation applications into the four categories represented in Table 1 (Shubik & Brewer, 1972). While some of the applications may have changed since the 1972 Rand study, the categories are still relevant today.

TABLE 1

SIMULATION APPLICATIONS

Industrial-Operational	*Teaching and Training*	*Political-Diplomatic-Military*	*Research*
Mining engineering	Urban development and planning strategies	Social-economic analysis	Environmental system development and design
Apparel processes	Nuclear power plant training	Strategic wargaming	Virtual surgery
Machine simulators	Dispatcher and operator training at electrical utility companies	Peacekeeping and disaster assistance	Space exploration equipment

(Revised from Shubik & Brewer, 1972)

Simulators allow operators to learn and practice for normal, abnormal and emergency procedures in a near-realistic setting and provide accurate real-time feedback (Inui, Myojin, & Oba, 1993). The context of the situation allows the users to visualize the system's interrelationships much clearer than abstract concepts. Realistic concepts cue the user's abstraction of the situation so users can respond better to tasks which enhance their mental model of the process (Inui, et al., 1993). The features of simulation-based training which they identify enables learners to:

1. experience "the objective world in imaginary environments" and create mental models from this,

2. not become bored with the simulation, and

3. grasp concepts easier through visualization than by trying to understand abstract concepts (p. 263).

In addition to the applications listed in Table 1, Inui, et al., (1993) also indicate simulations are utilized for instruction in nuclear power plant operations, troubleshooting systems, physics, chemistry and language education. An example of how various other domains have benefited by employing simulations is provided in Table 2.

TABLE 2

SIMULATION BENEFITS

Event/Domain	*Result from Simulation Training*
Landing on the Moon (NASA)	Actual training not possible on Earth
Top Gun Fighter Weapons School (U.S. Navy in Vietnam conflict)	Improved Navy exchange ratio in air combat over North Vietnam 2.4 to 12.5
Commercial Airlines (U.S.)	FAA: Simulator Training alone qualifies a pilot to fly a new airplane for the first time on a revenue flight
Nuclear Power Plants (U.S.)	No significant accidents (after Three Mile Island) in military and civilian operations
Canadian Armor Trophy (Military Armored forces in Europe)	Extensive simulator training helped U.S. Army win for the first time in 1987
Battle of 73 Easting (U.S. Army in Desert Storm)	Participants report that success in battle was based on tactical experience gained in simulations

(Revised from UCF IST, 1993)

Simulations justify their utility for training. However, simulations do not always achieve a significant return-on-investment often because planners have not matched capabilities against training needs. A systematic approach to simulation training effectively develops crew confidence to prepare for a diverse set of emergencies and increases familiarity with procedures (Roth, Mumaw, & Pople, 1992). However, the accomplishment of this goal does require the trainer to review the simulation's limitations and capabilities. One limitation concerns the ability of simulations to foster a training plan and environment which will increase trainee proficiency. To improve human reliability in the nuclear power plant industry and all simulation application areas, key events are needed to stimulate active reasoning during simulations (Roth, et al., 1992). The manager for the simulation must ensure that key events have realistic meaning to the participants and stimulate the correct responses for training.

Another limitation of simulations is that many degrees of difficulty are needed as scenarios change to support all training levels (Spurgin, Moieni, & Orvis, 1993). The result is the creation and management of an exponentially-increasing database of scenarios filled with exercise details and objectives (Pemberton, Classe, Bradley, & Wilson, 1994). These scenarios are often site-specific, single-domain scenarios which permit little flexibility in sharing and reusing scenarios in multiple domains.

The future direction of simulations can best be illustrated through the aviation industry and the military. Both groups employ simulations to save training time and reduce risks. Flight simulators, wargames and military tank simulators are examples. In

terms of current and future funding, it appears that the most predominant customer for simulations is the military. Confronting a new horizon filled with multiple global missions, the military continues to invest in a simulation-based training environment to offset drastic cuts in training areas, units and personnel. Applying new technologies in its training programs, the military looks more to simulations as an essential means for increasing training readiness.

Estvanik (1994) declares that wargame simulations are used to test the participants on their strategic and tactical decision-making given partial information distorted by time. Advances in computer simulations permit the military "to train and equip forces far more effectively and efficiently than ever before" (Krepinevich, 1994, p. 23). By 1997, the U.S. Army intends to spend "about $750 million on the acquisition of simulators and another $400 million on research and development" (U.S. GAO, 1993, p. 2).

For similar reasons as the military, civilian industries have embarked on parallel courses in preparing and training personnel to operate in dangerous, stressful and complicated environments (Keiser & Seeler, 1987). As the level and complexity of the Distributed Interactive Simulation (DIS) exercises increase to accommodate geographically-dispersed, telecommunicated-events, planning needs expand exponentially. If the training scenario development and task assessment procedures are integrated with each other automatically, then the construction of DIS simulation training exercises could be a seamless, computer-based process with less room for errors and

more time for training (Kazarian & Shultz, 1994). The transfer of military simulations to civilian use is likely to follow the same path as other military initiatives similar to research programs which developed the Internet. With the large amount of simulation efforts devoted by the government, industry and academia, research and development should be conducted to ensure effective and efficient planning of simulation-based training.

The benefits and capabilities of simulations have been demonstrated through numerous examples in multiple environments. Simulation-based training does have limitations which must be accounted for in planning for training exercises. For the military and civilian training infrastructures, future indicators imply that simulations will continue to contribute to the overall success of training. Since the military is one of the predominant users of simulations for training, an example of a combat constructive simulation will now be discussed.

Janus Simulation

For the purposes of this study, the scope of the training systems will be limited to those simulation-based training systems. This focus is critical since there are many trainers, model mock-ups and instrumentation systems in the training systems domain. One of the constructive team training simulations used extensively by the U.S. Army and U.S. Marine Corps is the Janus simulation.

Janus is a next-event, stochastic, Monte Carlo simulation which allows exercise participants to train on the command and control of their respective units in an artificial combat environment. The Janus combat simulation program is written in FORTRAN 77 and functions within a UNIX operating system. The Janus simulation depicts a military ground and air battle from the perspective of up to six sides of forces. From the five levels of training defined by Turnage, et. al. (1989) and discussed on page 21, Janus can be categorized as a multi-unit system for operational training.

The fidelity of the Janus simulation stimulates players to visualize battlefield concepts in dynamic, and seemingly realistic training scenarios. Since the Janus simulation is prevalent at many military installations as a training system for planning teams, it was selected for this study.

This section has discussed the merits of systematic training models, team training, and simulations. Based on the preceding literature review, there is a requirement for a training model designed for team simulation-based training similar to training with the Janus simulation system. The next section will provide a review of methods for developing training plans which incorporate simulation-based training models.

Training Plan Development

To examine the training plan development area, present methods, as well as building mental models of the training plan development process will be detailed. Training plan development is the process of identifying training goals, objectives, needs,

resources, action and evaluation for a particular training event. Rouse and Howard (1993) remarked that one significant problem is that, in general, poor plans are caused by deficient connections among objectives, strategies, and agendas. Rouse and Howard (1993) also contend that many people do not receive training on how to create a well-developed and efficient plan. Those who are not trained in planning also have to research organizational practices and procedures in order to initiate the process.

Present (Manual) Methods

The need for a training planning model exists to ensure training objectives are met by the organization. To accomplish the training for an organization, Sloman (1994) suggests that the trainer must be able to apply information, resources and management support. As a result, training is carefully crafted to ensure that training tasks match training objectives.

Planning is an information-intensive, processing system which is very manual. Instead of minutes to do planning for simulation exercises, Pemberton, Classe, Bradley, and Wilson (1994) contend that manual planning processes require weeks or, in some cases, months. A training guidance document is a manually-intensive effort to align a training planner's objectives with the training model in the organization. This process assists in showing the planner how to orient training on the users, tasks and models. According to Tolbert and Bramwell (1992), the training planner's needs are satisfied by such a tool:

> A training guidance document, like a review plan, can be a valuable aid in promoting effective training practices. It can improve understanding of what constitutes efficacious training and can be used to secure and maintain optimal levels of trainee performance. As a result, reliable plant performance can be supported (p. 495).

To provide information on training development processes and teach the proper methods for developing training, Tolbert and Bramwell (1992) also assert that a training guidance document should be the basis for a training plan:

> 1. The organization of a training guidance document relays important information to the user. It should be an accurate portrayal of the relationships among all system elements relative to training.
>
> 2. The type of information, amount of information, and level of detail to be included in a training guidance document depend on the users and their tasks.
>
> 3. Common and well-understood terms support the development of a widespread common model of intentions.
>
> 4. A proper mix of comprehensiveness and detail facilitates the document's user's tasks. (p. 494)

As shown in the preceding examples, the manual-based practices in training plan development have been and are likely to continue as the norm for training developers. The end result has been masses of documents and paperwork created, maintained and often underutilized throughout the training planning process. As planning and its inherent complexity are considered, there appears to be a need to develop an effective representation of the training planning development process. Future training plan development methods promise to alleviate this manually-intensive workload.

Mental Models and Training Plan Development

Definition and development of mental models

The theory of mental models emerged from several studies which include problem solving research reported by Newell and Simon (1972), and Anderson's (1981) work in cognition. Johnson-Laird's (1983) study asserted that acquiring an expert's mental model of a task to guide design empowered individuals to adopt the characteristics required to think critically by applying the expert's mental model as their own model for solving problems (Chapman & Allen, 1994). Bayman and Mayer (1984) termed a mental model as a "metaphor consisting of the components and the operating rules of the machine" (p. 189). The research of machine operator tasks by Moray (1987) views mental models as "quasi-independent subsystems into which the total system can be decomposed" (p. 619).

Johnson-Laird (1983) asserts that "mental models owe their origin to the evolution of perceptual ability in organisms with nervous systems" and thus the primary source of mental models is perception (p. 406). Johnson-Laird credits Kenneth Craik as the first to consider modeling mental processes when Craik "proposed that thinking is the manipulation of internal representations of the world" (p. x). The procedure for confirming statements regarding mental models emanates from a perceptual skill or activity which relates written text to the environment.

Mental models embrace all aspects of a system from its physical objects to its associated abstractions and idealistic concepts (Lindegaard, 1987). Mental models are an

individual's representation of, or "are used to arrange", information into a structure which allows versatile storage and retrieval of information in terms of features related to situations, entities and environmental conditions (Tannenbaum, Cannon-Bowers, Salas, & Mathieu, 1993). The basis of a system is patterned after the expert's mental model is sometimes called the "cognitive task model" or "cognitive simulation model" (conversation with Dr. Kent Williams, March 1996). For this study the definitions of components described by (Norman, 1983) will apply. Norman states that "in consideration of mental models we need really consider four different things: the target system, the conceptual model of that target system, the user's mental model of the target system, and the scientist's conceptualization of that mental model" (p. 7). For the user, mental models evolve naturally through interaction with a target system based on the user's background and expertise (Norman). The scientist's conceptualization of a mental model (which this study seeks to capture for automated training plan development) is "a model of a model" (Norman, 1983, p. 8).

Johnson-Laird (1983) summarizes the development of mental models by explaining that:

> 1. they derive from a relatively small set of elements and recursive operations on those elements; [and]
>
> 2. their representational power depends on a further set of procedures for constructing and evaluating them (pp. 429-430).

Johnson-Laird (1983) has recognized that mental models vary in form, purpose and contents. "The mental model is constructed on the basis of the truth conditions of the propositions expressed by the sentences in the discourse" (Johnson-Laird, p. 407). Since text can be imaginary or fictitious, its ability to represent a single, well-defined model is difficult due to its propensity to encompass a multitude of states. Additionally, Johnson-Laird stipulates that mental models easily embody certain concepts, while other concepts are not so easily represented with mental models.

Staggers and Norcio (1993) contend that mental models are formed through metaphors or analogies to assist in structuring new domains. Along with this premise is that people usually begin building their mental models using preconceived analogies from similar or related systems. Staggers and Norcio (1993) point out that even though there are researchers who either support the analogy or metaphor approach for building mental models, there are more important processes to consider:

> Whether one calls entities analogies or metaphors seems less important than the overall notion that these entities serve as model construction devices. Instead of being strict entities by themselves, these smaller objects may serve as the genesis for a larger mental model of a new domain of knowledge. Users may transfer knowledge about familiar systems to new systems in the form of visual phenomena known as either analogies or metaphors. At times dissimilarities may be the impetus for the construction of new relations or structures; however, users may not reject analogies or metaphors even given the presence of dissimilarities...(p. 591).

The development of a person's mental model is an abstract construction of modeling a domain of knowledge about a certain process. The relationships among the

input and output results from certain activities within a process. The development of mental models reflects a person's thinking about situations, but there are still aggregation of models or processes within a person's mental model which are unknown and thus impossible to capture. The differences between novices and experts may help to explain some of these ideas on development.

The complexity and completeness of a mental model vary according to a person's background, knowledge and experience. Staggers and Norcio (1993) expect "that naive users not only commit mistakes more often but also commit more serious mistakes than experts" (p. 595). The expert's performance overshadows that of the novice in that experts tend to structure and recall large amounts of information easier than novices (Schvaneveldt, Durso, Goldsmith, Breen, & Cooke, 1985).

In computer programming Cañas, Bajo, and Gonzalvo (1994) report that "the conceptual structures of novices and expert programmers have indicated that experts not only possess more programming knowledge than novices, but [experts] also organize the knowledge differently" (p. 796). The experts tend to synthesize their programming knowledge for a deeper understanding and application, while novices show superficial knowledge of the programming language. Staggers and Norcio (1993) support this premise by stating that many authors concur that the expert's mental models are abstract, while the novices' models are more concrete. Experts possess the ability to merge imaginary entities with real entities in order to create and refine higher level conceptual models (Staggers & Norcio).

Research in computer-aided mental modeling indicates that the designer's conceptual models revealed through user interface design would enable novices to "develop better mental models and thus perform tasks more like experts" (Shih & Alessi, 1994). A novice could apply the mental model of the expert to begin responding or acting as an expert. The designer must not only design a system which increases the "users' abilities to create appropriate mental models" but also know how the users think about the system (Staggers & Norcio, 1993, p. 595).

The breakdowns in the development of mental models must also be considered when examining how mental models are formed. In fostering mental models, Staggers and Norcio (1993) emphasize that designers build a model which increases users' abilities to create a mental model of the system. Johnson-Laird (1983) aptly realized that developing a usable and complete mental model theory would include major constraints which result from:

1. the perceived and conceived structure of the world,
2. conceptual relations governing ontology, and
3. the need to maintain a system free from contradictions (p. 430).

Mayer (1989) defines conceptual models as those which create mental models through text and graphics that depict the major activities, causalities and components in a system. Mayer asserts that "conceptual models can provide an assimilative context for students to build useful mental models" (p. 61). If the conceptual models are ill-defined

or incomplete, the resultant mental model in the subject or student is also inaccurate. A mental model may not always match the complete and accurate mental model that the designer intended. Cañas, Bajo, and Gonzalvo (1994) suggest that "a mental model might contain more or less details of the components and rules of the system and may match more or less closely the real characteristics of the system" (p. 795). The user may have preconceived ideas and mental models which supplement or fill in missing components of the modeled system's process.

The development or evolution of mental models in people adhere to these constraints. Everyone understands and perceives conceptual and physical models concepts in a different manner than others may. A person's mental model is the understanding of the relationships between the input and the output to predict, after the development of an accurate mental model, the output which could be produced for the possible inputs (Eberts, 1994).

Johnson-Laird (1983) proposed that the theoretical aspect of mental models should result in a complete and accurate model. However, the mental model's content is "both a function of the model and the processes that evaluate it" (Johnson-Laird, 1983, p. 408). The iterative construction of mental models results from reasonable, yet biased, assumptions. The model is recursively modified if the assumptions are incorrect. The end result is that the model may embed inconsistencies which do not readily reveal themselves.

Another aspect of recursive iteration is what happens when users stop forming their mental models of the process. Moray (1987) hypothesizes that skilled operators develop a rigid and inflexible mental model once they are content with their level of learning. The danger here is that the unbending mental model shatters when an unknown situation is encountered. "Instead of being triggered by discrepancies to pursue induction, they [operators] desperately try to fit data to their existing models and are typically very inflexible" (Moray, p. 628). In this case, the mental model ceases to develop into a complete and mature representation of the entire environment in which the operator must function.

There are several ways already known to enhance the completeness and accuracy of mental models. First of all, the conceptual model of the target system, such as the training planning development process, should be designed using subject matter experts (SME) (Norman, 1983). If there is a lack of user or SME input in the design process, the system will only partially convey the intended model and most likely confuse the users.

Secondly, the mental model should be verified to determine that it follows and includes the components of the process under consideration. To verify the mental model, a system is needed for recording the tasks, input and output variables, and the relationships in the process. In this manner, the verification and implementation of the system will evaluate the flow of actions triggered by a correct mental model.

There are several methods available for conveying the conceptual model of a system for users/evaluators to create their own mental models. The Goals, Operators,

Methods and Selection (GOMS) methodology is a hierarchical goal decomposition method proposed by Card, Moran, and Newell (1983). "The GOMS analysis technique is also compatible with the recall of procedural knowledge since it is based upon the production theory of learning and memory which has received empirical support in the research literature" (Williams & Kotnour, 1992, p. 57). GOMS is one of the procedures which enables the identification of conceptual models of target system tasks using knowledge statements which describe a process.

Cognitive complexity models describe the essential procedural knowledge in terms of a production system architecture. Bovair, Kieras, and Poulson (1990) state that "like the GOMS model, cognitive complexity models are descriptions of the knowledge required to use systems and are not intended to be complete simulations of the actual mental processes of the user" (p. 5). Bovair, et al. applied the production system as the basis of the cognitive complexity model due to its widespread acceptance and success by other researchers.

The production system includes "a working memory, a collection of production rules, and an interpreter" (Bovair, et al.). Each of the components of the production system function to model the way humans think. The working memory represents current environmental goals and inputs, as well as, previous information which explains previous and current states of activity. The production rule is an IF-THEN statement indicating condition-action pairs to describe the external environment or working memory. Switching between recognition and action cycles, the interpreter evaluates rules

and acts in a predetermined manner. The production rule system has been used in many systems in applied cognitive research (Anderson, 1987).

<u>How mental model theory has been applied to design in the past</u>

Mental models evolve from the user's previous experience, knowledge and perceptions related to a system (Wilson & Rutherford, 1989). Evaluation of users' mental models is frequently accomplished by measuring learning, efficiency workload or time performance. Qualitative and subjective evaluation methods query whether the subjects were able to increase their understanding of the particular process.

Bayman and Mayer (1984) declared success in conveying the conceptual model of a calculator stating that "mental models can be explicitly taught to users of electronic computing devices, and that these models can enhance the level of sophistication of user performance" (p. 198). The initial results showed success, but there was still a need to improve the calculator conceptual model for a broader base of users. Bayman and Mayer suggest that further research is required to iterate and find the best conceptual model for helping more people understand how calculators operate.

A mental model proposed by Chapman and Allen (1994) exercised cognitive task analysis research for designing mass-production of maintenance multimedia courseware simulations. The authors declared success when they were able to demonstrate the improvement of users' mental models through teaching cognitive troubleshooting

strategies in actual situations. Verification of the mental model was achieved by applying the tasks in a realistic environment.

McAlindon (1994) reported successful results in using mental model theory to represent the linear QWERTY keyboard structure to build his patented Keybowl. The mental model of the QWERTY keyboard was identified and then used in modeling the Keybowl to determine where to place the characters and convey the mental model of typists. "The Keybowl typists indicated that Keybowl typing was easy to learn because of its QWERTY compatible mental model coded character schema and visible character arrangement" (McAlindon, p. 166).

For the definition of success in a mental model theory application, there are many possibilities relevant to all domains. However, sometimes the results are convoluted with external or internal factors which fail to reveal the importance of the mental model theory.

One of the most intriguing factors involved in determining a user's mental model is the transfer of knowledge. A mental model may not change significantly until major increases in learning have occurred. This interesting feature arose from the study by Cañas, Bajo and Gonzalvo (1994) in that the novice programmers who received limited programming instruction in the test did not improve performance. More programming instruction and learning were deemed essential to enable the novice programmers to adequately improve their mental models of the programming process.

Relating the concept of mental models to team planning, Stout (1994) sought to show how shared mental models enabled team members to understand one another's informational requirements. The difficulty here was capturing not only one mental model, but understanding and finding the synergism of several mental models for team members who function in distinct, yet contributive tasks. Team training planning is an area in which the literature is not extensive, and there are only a few "empirical investigations of planning in teams" (Stout, p. 63). Stout's team research is a good start, but more work needs to be done in multiple mental models before success can be declared in this area.

How mental model theory can be applied to the planning process

Developing accurate mental models are critical to planning for simulation-based training. The computer-based tool incorporates and transfers the appropriate conceptual model to the novice planner. To enable a novice trainer to embrace some of the training plan developer's expert's knowledge, it is essential to capture the expert's mental image of training plan development. Computer-based training planning tools are now examined to determine their utility and feasibility for assisting novices in forming a mental model of training plan development.

The complexities of concepts and actions within the systematic training planning process for simulation-based training warrant the application of an expert's mental models in the design of computer-based planning tools. Rouse and Morris (1986) assert

that complex situations such as developing training strategies are ideal for mental model theory application. Pietras and Coury (1994) affirm that a cognitive model of human planning behavior could represent the planning process.

"Managerial planning tasks, usually referred to as strategic or corporate planning, involve a series of mental processes preceding or leading to the taking of important decisions about the future course of a firm" (Marmaras, Lioukas, & Laios, 1992, p. 1222). The criticality of planning for simulation-based training has equal importance for training to perform in stressful and dangerous situations. The transformation of training planning concepts suggests an extension of mental models to build the expert's view of the system. In a training planning system, the expert's view or mental model generally follows the heuristic systematic training planning steps to ensure appropriate relationships and procedures are accomplished.

For training plan development, a variety of tasks and objectives are performed by the planner in organizing, executing and refining effective training. The development of a mental model which follows an accurate model of the training plan development process seeks to transfer the knowledge through an automated process versus conventional manual methods. "Computer users are generally required to acquire the structural information of systems and individual tasks in a manner which is incidental to their main task objectives" (Stanney & Salvendy, 1994, p. 607). The system requires the user to provide certain information in order to conduct the tasks which fulfill the major requisites of the system. Kline, Blickensderfer, Dryer and Bochenek (1995) reiterate this point by

stating that "as the system queries the user for information about the problem, the user should begin to build a mental model of what the system is doing" (p. 195).

The proper design of an automated planning tool enables the novice to build a mental model of the training planning process. The validation of this statement requires examination of how automated planning tools are better than manual planning methods for training planning, as well as, the effects that an automated planning tool have on the mental model of a novice planner.

Corroborated by Merrill, Li and Jones (1989), the need for computer-based programs is permeating all domains of industry:

> The impact of computerization on other fields has been to increase productivity by reducing labor costs, or allowing greater production from the same labor. Personal computers probably owe their success to the electronic spreadsheet. Every financial planner could immediately see the efficiency of using an electronic spreadsheet. Tasks that at one time might require days or weeks could now be accomplished in minutes or hours (p. 10).

Similar to the preceding statement, there are currently many promises whereby technology is seen as a viable means for increasing the efficiency of conducting routine tasks. For planning, Tolbert and Bramwell (1992) remark that computer-based planning tools are essential to guide the planning process. Tolbert and Bramwell outline an approach which defines training guidance documents as a methodology for organizing the the training planning process. However, the proposed process is too complex and intensive to rely on manual procedures and techniques. When training and planning are

coupled with simulations, the manual requirements become an unmanageable burden of input and output variables intertwined into relationships within the modeled process. Table 3 highlights the functions in automated planning tools for simulation-based training.

TABLE 3

AUTOMATION ROLES IN TRAINING PLAN DEVELOPMENT

Area	***Function***
Procedure	Remembering the essential steps in training plan development
Planning context	Visualizing (or understanding) a training plan as it unfolds
Information management	Filing, storing and retrieving training plans and scenarios using routine and systems design principles
Automation	Using technology to solve a problem
Simulation-based training	Automating the efforts normally required for rebuilding and initializing simulation scenarios
Editing	Incorporating changes to training plans
Training status	Updating proficiency ratings

The abundance of information and processing activities in the training plan development process warrants automated assistance to ease the cognitive or mental burden on the user. Helander (1988) states that "cognitive psychologists have viewed human cognition as an information-processing activity with many similarities to computer systems" (p. 893).

Given that it would require a novice a considerable amount of time and numerous opportunities of exposure to the training plan development process for simulation-based training, the use of a computer-based system for planning training is viable. The cognitive and perceptual requirements for the training planning process require the training planner to utilize the functions listed in Table 3. In order to visualize and focus on this process, automated planning tools will enhance the novice's abilities to adopt the expert's view of the training plan development process.

Since training plan development encompasses the arrangement of information for a specific environment, the use of mental models theory in designing planning information for training merits further research. The associated input and output and relationships of goals and plans are the key elements of the training plan development process. Using a cognitive analysis approach, production rules can be developed from these elements to represent the mental model of an expert training plan developer of simulation-based training.

Helander (1988) alleges that a computer-based information system should support the development of the mental models essential for conducting the functions of a process. The requirement to acquire a mental model of training planning is critical for success in simulation-based training. The planning tool's display structure must accommodate fostering and building of mental models for novices and inexperienced users to understand the training planning process.

In order to assist users in building an appropriate mental model, the interface design must convey information on the relationships and processes within the training plan development process. Building a mental model of an interface can reduce complexities in an interface if the number of operations to accomplish a task are consolidated. For computer interfaces, Eberts (1994) espouses that three areas are effective for developing concise mental models of a system:

1. active interaction with the computer,

2. the use of metaphors and analogies to explain the system, and

3. the use of spatial information to convey the conceptual model (p. 162).

First of all, in order to develop a concise mental model of the training planning system, users need to be able to explore and test the effects of input actions on the computer without being penalized by time losses or serious errors (such as loss of program control). Eberts (1994) also suggests that words and symbols induce the users to explore the system further. A training planning system would apply recognizable, domain-specific vocabulary and icons to enable the users to begin building a mental model of the designer's conceptual model of the system.

The next consideration for designing computer-based tools using conceptual models is that a training planning system presents users with metaphors and analogies which will teach the conceptual system's mechanics and operations. Metaphors and analogies based on concrete images related to the training plan development process

enable novices to accomplish tasks that require synthesizing training planning knowledge. One metaphor in a computer-based planning tool could be a clipboard to represent the process of assessing task accomplishments.

The third important system feature requires spatial representation of the designer's conceptual model. Presenting a "picture" of the system's components, inputs and outputs, or overall structure, graphical representations seek to assist the novice in visualizing the designer's conceptual model. This feature implies that the automated planning tool's layout permits the user to visualize the training plan development process since the computer-based tool guides the user through the process of completing the planning tool's steps and procedures. Consequently, as users become more familiar with the procedures, they will begin to learn and visualize what the inputs and outputs are in relation to the training plan development process without having to follow all of the steps in the system.

In a training planning system, experts must be able to convey the process to novice users. Managers and corporate leaders frequently task novices to conduct training planning activities. Hollnagel, Hoc, and Cacciabue (1995) state that "expertise can be defined as the knowledge that a person can bring to bear on a situation" (p. 279). A user interface design which mimics the expert's conceptual structure of a training planning process thus may enable the novice to apply the same knowledge an expert would use for training plan development.

In a manually-oriented method, the novice training planner follows written guidance documents and procedures, but fails to understand or grasp the essence of the planning exercise until gaining sufficient experience in conducting planning for simulation-based training. The computer-based training planning tool may enable the novice to learn quickly the training development steps while visualizing the process and receiving cues to guide progress. The implication is that if a training planning tool closely mirrors the expert's view of training planning development, then the novice planner may create an accurate mental model (Eberts, 1994). Therefore, the automated planning tool should attempt to model the training plan development process in such a manner that the tool's interface conveys the expert's mental model of how training plan development works. As discussed in the next section, there are important shortcomings and weaknesses to consider in this area.

Mental model theory weaknesses/potential pitfalls

The most significant weaknesses and potential pitfalls in using mental model theory emcompass the user's mental model development. Johnson-Laird (1983) stipulates that the concepts of "time, space, possibility, permissibility, causation and intention" (p. 413) affect how users would comprehend a conceptual model of a system. The textual and graphical references in the software planning tool may be insufficient to create an accurate and complete mental model. Consequently, an individual's mental model may function to a certain level, but not as complete as intended by the designer.

The user's mental model of the system should be verified and checked prior to assuming that the novice or inexperienced user fully grasps the conceptual representation of the designer. The need for verification of the user's mental model applies to the training plan development process. The background, knowledge and experience of the training planners affect their perception of the mental model's semantics and representations of the training planning system. The results may be inconsistency and inaccuracy in development of a training plan.

Next, the designer is also responsible for the development of conceptual models. The construction of a universally-acceptable conceptual model is frequently unattainable. Eberts (1994) states that one problem with GOMS is that "different task analyzers may develop different task analyses for the same task (p. 365). There is a need to build on several iterative revisions of the conceptual model to develop an approximation of the process. It is the designer's responsibility to consolidate these revisions and create systems which enable users "to develop more coherent, useable mental models" (Norman, 1983, p. 14). For training plan development, there are many experts and task analyzers who have different interpretations of the training plan development process. However, these differences need to be reduced by compromise and adherence to the fundamental concept of the systematic training model with planning enhancements.

Last of all, the experimenter's ability to measure the initial and resultant mental models of users may lead to inconsistencies in recursively designing the conceptual model portrayal to the user. There are methods to determine whether the user's mental

model is developing as the designer had intended, but they sometimes do not reveal practical relevance to a dynamic or evolving system. Inaccurate assessments could affect the mental model's production and understanding. Consequently, the user, designer and experimenter must work together to develop and evaluate the system which will convey the most accurate and complete conceptual model.

Computer-Based Training Planning Tools

Currently, training proficiency, task selection and prioritization, training conditions and effectiveness measures, must also be processed and integrated by manual planning methods to match training needs against training simulation capabilities, limitations, and resource availability. This time-consuming, complex process often discourages the novice training planners from considering the use of simulation-based training.

There are both planning tools and training planning tools which use computers. The planning tools in today's market vary from generalized project planning packages to specialized decision support programs.

General Planning Tools

The category of general planning tools does not focus on any one component of planning or its relation to domains such as training. Instead, the overall review of general planning tools is explored to determine how planning tools can assist the user in conducting tasks in the organization. "Tools for decision support and scenario analysis

allow for a uniform merger between spread-sheets, databases, financial modeling systems, etc." (Parsaye, Chignell, Khoshafian, & Wong, 1989, p. 421). Similar to planning systems, decision support systems are considered "a special kind of information management, retrieval, and utilization, where the information is tailored towards particular decision making activities" (Parsaye, et al., 1989, p. 421).

For "corporate and strategic planning, tasks involve a series of mental processes preceding or leading to the making of important decisions about the future course of a firm" (Marmaras, Lioukas, & Laios, 1992, p. 1223). The overall objectives of a planning tool are to expand on these features incorporating information manipulation for the purpose of meeting goals and objectives.

Pietras and Coury (1994) assert that no one has investigated the "potential utility of theoretical research in planning" (p. 6), e.g., for developing project management tools. With similar considerations in the training model and its planning process, these tools could also be used for training plan development. Pietras and Coury (1994) contend that their cognitive model:

1. identifies the goal and plan structure of the planning process, and

2. captures the levels of reasoning and abstraction inherent in planning for project management. (p. 6)

Project planning packages contain information to track performance, costs and schedules of programs (Senn, 1989). Some of the characteristics for successful project planning relate to the discussions of training planning. There are various types of

planning methods in the sciences. "Mathematical programming has been traditionally used for planning large and complex systems. Some examples include air-traffic control management, scheduling power generation and transmission, transportation planning, and manufacturing and distribution scheduling" (Zenios, 1995, p. 195).

Management of information systems often involves various planning techniques. Developed in 1958 for the U.S. Navy by Booz, Allen and Hamilton, the Program Evaluation and Review Technique (PERT) is one of the most practical planning methods (Senn, 1989). The PERT program is incorporated into software packages such as Microsoft Project© and CA-SuperProject©.

For an organization or corporation to build a plan, the process continues to be an elusive and frustrating one. Rouse and Howard (1993) contend that computer-based planning tools can significantly improve the effectiveness and efficiency of plan generation. To illustrate this point, Rouse and Howard (1993) have built a computer-based planning tool to assist corporations with the complexities associated with corporate marketing strategic planning. The primary focus for this application is on planning methodologies for marketing strategies and is "augmented with on-line tutoring and expert advice" (Rouse & Howard, 1993, p. 52).

Some research references there is potential for applying computer-based tools to alleviate the burdens of information overload. Kelleher (1993) exploits the potential for applying computer-based planning tools for information processing systems.

Planning methods and procedures abound in industry, academia and government, but there are few planning tools designed to prepare users and managers for the simulation-based training. For many planners and users throughout industry, training simulation scenario preparation requires hundreds of hours for preparation, execution and review. The goals, plans and levels of abstraction in training planning are similar to those in project management, suggesting the potential for use of this concept for future training plan development methods. The project management planning techniques reflect those used in training plan development.

Existing Training Planning Tools

This section will highlight research and developments, in both the civilian and military sectors, regarding the use of planning tools for simulation-based training. Throughout industry, analysts and observers assert that technology and automation should enable people to conduct routine tasks (Hollnagel, Hoc, & Cacciabue, 1995). For these reasons, the implementation of computer-based planning is essential to simulation-based training. Relative to planning, Tolbert and Bramwell (1992) remark that computer-based planning tools are essential to guide the planning process. Researchers have only started to address the importance of using computer-based planning tools to prepare for simulation-based training. This situation is reflected in the civilian sector. On the other hand, the military is beginning to prototype several computer-based approaches to assist in the planning of simulation-based training.

Civilian

There are already instances of automated training planning tools being developed in academic instruction and training. Drewes and Gonzalez (1994) discuss a methodology for assisting instructors in monitoring students training on flight simulators. This methodology includes real-time evaluation feedback to allow instructors to monitor the training with the use of template-based training goals, subgoals and standards. The components of this computer-based training system encompass training performance monitoring, on-line comparisons against standards, and immediate feedback to the instructor or student. All three of these functions are automated as part of the training plan development process.

Data analysis and measurement of meaningful results also require improvement. The nuclear power plant industry is exploring ways to improve this area in the use of simulations for training on power plant accidents (Spurgin, Moieni, & Orvis, 1993; Roth, Mumaw, & Pople, 1993). The training goals seek to build realistic and stressful exercises for nuclear power plant incidents. Roth, et al., (1993) have developed a systematic training approach for scenario development for simulator training. Their objective is to maximize the current use of simulator training time by infusing mentally challenging training scenarios into the operators' training program. Spurgin, et al. (1993) have sought to integrate simulator data collection methods and training effectiveness measures in order to assess crew performance in simulator exercises. These are just some of the ideas for automated training planning tools in training evaluation and review systems.

There were only a few examples of research and work in computer-based planning for the civilian industry. For the military, initial efforts are surfacing, but the verdict as to the success or contribution of computer-based training planning tools is still speculative.

Military

In recent years, the Navy's Automated exercise Preparation, Evaluation and Preview (APEP) training software program has led the way in automated systems for training planning (Pemberton, Classe, Bradley, & Wilson, 1994). APEP was originally proposed by Pemberton, Campbell, and Ahlers (1992) as a system which would generate scenarios by identifying and utilizing a "large amount of information to simulate a military engagement" (p. 2).

Paralleling the APEP efforts is a prototype planning program being developed by the U.S. Army. The Army's Training Exercise Development System (TREDS) described in Crissey, Stone, Briggs, and Mollaghasemi (1994) is an initiative to precipitate training plan development for simulations by capitalizing on computer technologies. The theoretical perspective on which both APEP and TREDS emanated resemble a cognitive model of instructional system design as described by Gropper and Ross (1987).

The Automatic Scenario Generator (ASG) is a predecessor to APEP. Specifically, this theory of scenario development proposed the following structure for training system scenario generation and modification:

1. establishing training objectives,

2. determining performance measurement criteria,

3. identifying initial conditions, and

4. preparing a timeline of events or track scripting (Pemberton, et al., 1992, p. 3).

The ASG program initiated by Pemberton, et al., (1992) was later converted to the APEP planning tool with limited features and functionalities in scenario generation. Pemberton, et al., (1992) also outlined in the ASG proposal the requirements for subject matter experts (SME) or instructors to conduct tasks analyses, develop creative and imaginative scenarios for students, and measure student performance. The objective was that automation would reduce the planning time and efforts of training supervisors, subject matter experts (SME) and other training personnel. These requirements and components are detailed in the succeeding descriptions of the APEP and TREDS programs.

The Automated Exercise Preparation, Evaluation and Preview (APEP) Tool

The need for preparing and responding to dynamic exercise challenges must be met (Pemberton, Classe, Bradley, & Wilson, 1994). To overcome the "time consuming and labor intensive" (p. 6-13) process of creating training scenarios, the Automated Exercise Preparation, Evaluation and Preview (APEP) tool was developed by the Navy

(Pemberton, et al., 1994). The APEP tool was designed to alleviate difficulties associated with exercise management and reduce errors in placement of forces for an exercise.

The forces who participate in global and national networked simulation environments have multiple constraints and requirements to meet in order to conduct a large-scale training exercise. APEP is a prototype designed to "reduce exercise preparation time from months/weeks to days/hours" (Pemberton, et. al., 1994, p. 6-13). To achieve this objective APEP has three main capabilities:

1. automated exercise entity positioning based upon a specific training objective,

2. automated platform scripting using computer generated entities, and

3. automated association of training objectives with performance measurement criteria (Pemberton, et al., 1994, p. 6-13).

The first APEP module to be prototyped is the Training Exercise Force Laydown (TEFL). The TEFL module uses expert system techniques to enable a training supervisor to develop difficult and realistic scenarios. The training supervisor specifies the general nature of the training (situation training exercises or events), establishes friendly and enemy forces to play in the scenario (task organization and condition assessment), and chooses tactical constraints and limitations for battle. After this information is entered, TEFL automatically initiates exercise starting locations, routes, navigational information, and weapons status for both sides (scenario conditions and initialization parameters).

The second module developed in APEP is for Distributed Interactive Simulation (DIS) training exercises. As an interface tool, the Automated exercise Distribution and Display (ADD) electronically mails the APEP output to DIS participants using the DIS protocol data units (Pemberton, et al., 1994). This tool will alleviate some of the initial scenario initialization and setup efforts, while providing an interface to other models under the DIS exercise simulation architecture.

The APEP program has sought to reduce planning and preparation time for simulation-based training in the U.S. Navy. The two goals of the APEP tool are to coordinate the initial laydown structure of naval forces and enable faster access to large amounts of data for the DIS simulation exercise. The initial prototype of the tool is still being evaluated, but its development has been accepted enough to warrant continued investigation of the concept for training plan development. The U.S. Army is in a similar position with its prototype for automated training planning of simulation-based training.

The TRaining Exercise Development System (TREDS)

Recognizing that future battlefield training and preparation for "other than war" missions will rely more and more on simulators and simulations, unit commanders must incorporate new ways to develop effective training plans (Crissey, et al., 1994). Innovative methodologies must be applied to the planning process to match essential mission training tasks against constrained training resources. The TRaining Exercise

Development System (TREDS) is a prototype system being engineered by the author to meet these needs in the U.S. Army.

The purpose of TREDS is to provide a computer-based system to minimize planning time and maximize the available training time. The training tasks, allocation of equipment and personnel, and the degree of difficulty for exercise conditions, must all be considered. Effective planning is essential for all of these factors to achieve training mission objectives.

Anderson (1987) asserts that in order to understand human cognition, a person needs to "understand both mental algorithms (procedures) and their implementation" (p. 467). The procedures and their implementation in the Training Exercise Development System (TREDS) were constructed from the mental models of SME's experiences using a cognitive analysis tool which develops production rules. The TREDS program is intended to provide unit commanders with the knowledge or cognitive requirements to conduct planning for simulation-based training.

To organize the training planning development system in TREDS, the structure includes four modules composed of training analysis, task organization, exercise selection and exercise development. As the TREDS Systems Engineer, the author utilized this study to assess the theory that automated planning tools like TREDS have the capabilities to reduce planning time, enhance training plan development, and provide information for future training. TREDS is used in this study as the computer-based planning tool for simulation-based training.

Replicating the Army training and evaluation process, TREDS has a computer-based procedure to convert training results (tactical measures of effectiveness (MOE)) into proficiency ratings. This process begins with the lowest task level to define the standard or criterion *a priori* for pass/fail (Go/No Go) tasks in training. At this criterion/standard level, the Army's current training assessment system resembles the criterion-referenced evaluation system described by Gonzalez and Ingraham (1994). The task ratings of pass or fail can then be adjudicated by integrating the simulation output of measures of effectiveness values. The ratings are finally aggregated through the subtask and task levels and rated as either trained, partially trained or untrained. To determine the overall training success and effectiveness, the trainer compares and assesses the collective team's proficiency status before and after the simulation.

The design of a computer-based planning tool requires a conceptual framework upon which the users can understand the process being modeled. A training planning system would have to incorporate the recognizable attributes and features which allow the users to develop a mental model of the conceptual system itself. Also, a training planning system must contain metaphors and analogies which will convey the conceptual system's mechanics and operations and assist the novice in understanding the conceptual training plan development process. This model enhances the user's mental picture of the system's components, inputs and outputs, or overall structure. All of these areas are important for the success of a computer-based planning tool to enable effective simulation-based training plan development.

Besides APEP and TREDS, as the study has indicated earlier, there are no computer-based planning tools capable of handling the requirements for planning simulation-based training exercises and events. The TREDS design which enables computer-based simulation-based training planning was developed by the author as a response to the military's need for automated planning of simulation-based training. The APEP tool developed by the Navy was considered as a potential planning tool. However, the APEP tool is still a prototype and is not as functional as the TREDS tool. Due to its lack of functionality, the APEP tool was not considered further. This study will now examine the measures of effectiveness applicable to a training plan development tool.

Measures of Training Effectiveness

Assessment methods for training planning tools are needed for ensuring that the training planning process meets training goals. These methods correlate directly with the factors involved in adopting new training strategies which use new training media such as simulations. Effectiveness is defined by Rouse (1991) as "the extent to which the structure leads to improved performance, makes a difficult task easier, or enables accomplishing a task that could not otherwise be accomplished" (p. 23). In an era of continued budget reductions, Djang, Butler, Laferriere, and Hughes (1993) reiterate the need for effective training planning and simulation integration:

> Training developers need a tool to assist them in determining how to mix existing, new and proposed training systems into effective, less costly training strategies. The tool would indicate which strategies fall within

> budget constraints, what the tradeoffs are between training effectiveness and cost... (p. 1)

While there are a variety of measures and assessment tools for evaluating individual or team performance, the appropriate measures must be selected for the training situation. The majority of training is often conducted without providing empirical results due to the unfeasibility of collecting data from an incorrect or inadequate training model design (Sloman, 1994).

In classifying measurement approaches, Rouse, Cannon-Bowers, and Salas (1992) identify three categories:

1. empirical modeling,
2. analytical modeling, and
3. verbal/written reports.

This study will utilize the analytical modeling and verbal/written techniques to assess the experimental data obtained at the conclusion of testing. First, the analytical measures which evaluate effectiveness of training performance are reviewed.

Performance

Plans are effective as long as they improve performance in the workplace and thereby contribute to the achievement of the organization's mission and objectives. Performance effectiveness should always be measured in quantitative terms, such as, reduced waste, increased sales, shorter production time, or fewer accidents (Spurgin,

Moieni, & Orvis, 1993; Fitz-enz, 1994). Being able to meet training goals by conducting the tasks correctly is a result of having an effective understanding of training plan development.

Programmatic Measures of Effectiveness (PMOE) assess performance changes in training and operational contexts (Department of Defense, 1993). Data analysis and measurement of meaningful results continue to be an area for improvement for industries such as the nuclear power plants (NPP) (Spurgin, Moieni, & Orvis, 1993). One key objective is to identify quantitative assessments of training performance results.

Searching for a way to measure performance effectiveness, Hall, Dwyer, Cannon-Bowers, Salas, and Volpe (1993) developed the Tactical Decision Making Under Stress (TADMUS) project. TADMUS utilizes key techniques in concept mapping, protocol analysis, cognitive task analysis, and cognitive networking to model knowledge requirements of team members for threat response management and situation assessment. The Anti-Air Warfare Teamwork Observation Measure (ATOM) evaluation in TADMUS measures four teamwork dimensions: situation assessment, communication, compensatory behavior and team coordination. The TADMUS program is depicted by the author's notes in Table 4 from an interview with one of the Navy's training system designers, Dr. Joan Johnston (December 7, 1994).

TABLE 4

TRAINING ASSESSMENT MATRIX FOR TADMUS

	Type of Training	
	Individual	*Team*
Process	Process Analysis	ATOM (measures of performance)
Outcomes (standards)	Rating Scales, Behavioral Observations	Team Standard Performance

The TADMUS and ATOM dimensions represent measurement techniques and organization which may be applicable for evaluating simulator training. Expanding the focus of this study, researchers could use these dimensions for training simulation exercises in emergency management centers, nuclear power plant command centers, and other military operations centers.

One area for improvement in the training development process is the organization of tasks and standards for establishing consistent training events and ratings across all units (Hall, et al., 1993). The quality ratings procedure used in the study reflects the quality rating process proposed by Cooper and Harper (1969) to quantitatively measure effectiveness on a consistent basis.

Cognitive mapping and clustering techniques define qualitative measures of the training planning tool (Gerjuoy & Spitz, 1966; Roenker, Thompson, & Brown, 1971;

Frankel & Cole, 1971; Nairne, 1991). The literature on psychological memory recall concerns techniques such as position memory (Nairne, 1991). Canas, Bajo, and Gonzalvo (1994) state that "it is possible to assess subjects' mental representation or mental models using tasks such as recall, categorization or relatedness judgments" (p. 797). This study examined these techniques for measuring the effectiveness of a computer-based tool to enhance a person's mental model or cognitive mapping of the training plan development process.

Plans are efficient if they make people effective in less time or with less money than it takes with alternative modes of getting people to perform (Parry, 1991). In other words, efficiency is dependent on effectiveness. It is a waste of time and money to make an ineffective plan more efficient (Parry, 1991). Assuming that a plan is effective, the focus will now be on the efficiency of the training plan development measurements.

Measures of Training Efficiency

In simulation-based training, measurements confirm whether trainers have created training scenarios to exercise the subject's cognitive skills in a variety of situations which encompass all major procedures (Roth, Mumaw, & Pople, 1992). The effectiveness of the training plan must first be confirmed prior to proceeding towards improving the training plan's efficiency. The efficiency of a system is the ratio of output of benefits divided by the input of resources. Planning and strategies impact on the efficient use of

resources. Two of the most important aspects of efficiency in simulation-based training pertain to costs, and the scheduling of resources and personnel.

Cost

In addition to effectively planning and conducting simulation-based training, the costs should be minimized as much as possible. Costs incorporate time, funding, and resources. Simulation participants, trainers and site managers must ensure that the exercise is well-organized and tailored to the training audience to avoid unnecessary expenditures. For some simulation exercises, "the most sophisticated [ones] run into a number of man-years and several hundred thousand dollars" (Keiser & Seeler, 1987, p. 466). In the military, costs for large-scale simulation exercises have been observed by the author to be in the millions of dollars. There are also months of manpower and facility usage devoted to these exercises.

Examining the expenses of training, Sloman (1994) states that "information systems on training are vital but neglected" (p. 141) and justifies capturing adequate training information for:

1. cost control,
2. the provision of information for decision making by line management, and
3. the provision of information for decision making by the training manager.

Costs are not always measured accurately due to the unknown variables which impact upon the simulation-based training exercises. To measure quality and productivity training costs, Smith (1987) provides a review of the techniques available. Some of these techniques highlighted by Smith (1987) and Sloman (1994) are related to costs in terms of time and money. The measurements are volumes of training activity and the costs associated with training (Sloman). Participation in training measured "in terms of days or hours of training received is the most accessible training metric" (Sloman, p. 145). For off-the-job training, these measurements are often inaccurately measured (Sloman).

The second part of measuring training resources is the monetary costs of the training. Sloman (1994) implies that costs are often difficult to measure due to the various methods organizations use in applying cost factors to internal training programs. External training programs are straightforward to measure costs, but the internal training cost measurements do not always use the same metrics and relationships in defining actual charging to various accounts (Sloman, 1994). As the cost of this study is weighed against the time involved in using the system, the same dilemma will likely surface. For this study, the efficiency cost will be related to the perceived operator workloads and recorded performance times.

One of the final considerations for cost is the method for recording training evaluations and data. Turnage, et al., (1989) note that with the move towards more simulation-based training, the Navy needs to look for better ways to automate data

collection and analysis for improving the efficiency of the training process. This aspect of training is often the last consideration for funding, yet it yields results critical to future training plan development. Equally important to measurement of efficiency as cost is, the factor of scheduling resources and personnel for simulation-based training warrants consideration.

Scheduling

To organize the training plan in order to meet its objectives, the efficiency of a schedule must also be measured for the time saved and output of training gained. McCord (1987) states that a schedule is essential to satisfactory planning and preparations in that it:

1. specifies what major topics will be covered with the trainee,
2. indicates what amount of time will be devoted to each major topic, and
3. assigns responsibility for each situation (p. 377).

In scheduling the simulation-based team training, various time considerations are required. The process involves capturing information for timing of events and synchronization of related tasks on a schedule. For training plan development with a simulation, Keiser and Seeler (1987) assert that the process is more complicated than conventional scheduling in that "the trainer must account for all practical contingencies, and prepare schedules, space, materials, personnel, and responsibilities" (p. 467).

Training time must be planned and scheduled efficiently with respect to the complexity and availability of resources and the variety of personnel involved. The measurement of training efficiency for scheduling, unlike cost considerations discussed earlier, is more qualitative than quantitative. Cost efficiency is a measurable quantity in terms of workload and time required to conduct tasks in planning simulation-based training.

Summary

Chapter 2 began with an overview of the training process including the training model, individual and team training, simulation-based training and the Janus simulation. This section also reviewed the systematic training model, types of training in teams, benefits and limitations of simulations.

Also included was a literature review related to current methods for training plan development. Present manual methods are widely used, but new methods are needed which can handle the intricacies of simulation-based training. To learn or plan faster and easier, there is the potential that novice trainers may be assisted through training plan development mental models.

The next section identified several computer-based planning tools available for general planning, training planning and automated planning. The literature search only yielded several automated planning tools. Likewise, for specific domains, such as market strategies and training, there were only a few computer-based tools available.

A final section focused on measures of training effectiveness and efficiency. Performance measurements were reviewed to determine the effectiveness of a training plan. Costs and schedules were considered to show whether a training plan is efficient. Table 5 summarizes the results of the literature review with the systems which apply to the components of this study, clearly showing the need for a computer-based planning tool to prepare for simulation-based training.

Planning enables effective and efficient training while the use of the planning process optimizes training time. Computer-based planning tools capture subject matter expert's (SME) mental models within the framework of the software tool to convey the complexities and functionalities inherent to planning for simulation-based training. With less opportunities for error and inefficient resource usage, the automated tool has the potential to enhance training proficiency, increase understanding of the training planning process, reduce costs, and build linkages to future training.

No planning tools are available which meet this need for simulation-based training. Knowledge and experience is essential for the training planning development process. Possessing limited expertise, novices must apply the correct procedures for conducting simulation-based training to ensure effectiveness and efficiency. An essential requirement for simulation-based training is the development of a tool which will automate planning tasks in the context of the planning process structure.

TABLE 5

LITERATURE REVIEW MATRIX

Author(s)	*Training Process*	*Simulation-based Training*	*Training Plan Development*	*Mental Models*	*Computer-based Training Planning*	*Performance Measurement*
Senn (1989)					X	
Tolbert & Bramwell (1992)	X		X			
Pemberton, Campbell & Ahlers (1992)	X	X	X			
Rouse & Howard (1993)		X			X	X
Drewes & Gonzalez (1994)	X	X			X	X
Pietras & Coury (1994)				X		X
Stout (1994)		X		X		X
Pemberton, Classe, Bradley & Wilson (1994)		X			X	X
Sloman (1994)	X		X			
Zenios (1995)					X	
Stone (1996)	X	X	X	X	X	X

As discovered from a review of the literature and the author's professional experience, research and development efforts in computer-based planning tools to enhance simulation-based training are currently very limited. The scope of the study would be too exhaustive if the study included all of the simulation users in academics, industry and government. Therefore, the study focuses on the government, and is further narrowed to the U.S. Army. For this experiment, the U.S. Army provided the testing subjects in its role as a proponent of simulation-based team training.

To assess the hypothesis that computer-based planning tools do enhance the effectiveness and efficiency of team simulation-based training planning, the computer-based planning tool used for this study is the Training Exercise Development System (TREDS). The Janus simulation is utilized for team simulation training. The methods and procedure for the study are now discussed in Chapter 3.

CHAPTER 3

METHODS AND PROCEDURE

This chapter details the research design, data collection, data analysis methods and procedures used in this study. Test subjects were from two U.S. Army locations: Fort Knox, Kentucky, and Fort Hood, Texas. Research data were collected during a week at each location. To maintain consistency among the two groups, a realistic training practical exercise was developed (see Appendix D). The study's main purpose was to assess the ability of computer-based planning tools for improving training plan development effectiveness and efficiency in simulation-based team training exercises.

Research Design

The research design method used in this study served to provide insight into the main question raised earlier-- *What contributions do computer-based planning tools offer to simulation-based team training?* To answer this question, three sub-questions were developed. They are:

1. Will a computer-based planning tool enhance the mental model of the training plan development process?

2. Are more effective training plans created and results achieved with computer-based planning tools?

3. Is simulation-based training planning more efficiently accomplished using computer-based tools?

Subjects

The study was conducted using U.S. Army personnel who plan activities and simulation-based team training for their units. Training planning is normally conducted by the leaders of the organization for their responsible individuals and teams.

The test population of the experimental study included officers and noncommissioned officers in U.S. Army Armor battalions in two separate locations. Within a large unit, such as a battalion of about 700 soldiers, there are approximately 80 key leaders involved in planning training exercises. Designating subjects for the teams to be tested was accomplished through coordination with unit leaders at Ft. Knox and Ft. Hood. Volunteers from this population included platoon leaders, platoon sergeants, training sergeants and company commanders.

Test subjects were familiar with simulations and planning for training processes in the U.S. Army. Subjects were randomly assigned to the respective experimental design groups in two-person teams which represented a standard assignment of personnel for planning and simulation training.

One requirement of a control-group design is to run two experiments simultaneously. Each location required at least one month to set up and organize for the TREDS experimental testing. The preparation for the experiment entailed conducting several onsite visits to introduce, anticipate, and coordinate with subjects and support

personnel at both locations. To maximize the statistical power of the test results, the research goal was to have at least 30 two-person teams for both the control and the experimental groups. For the test, the number of two-person teams which completed the experiment were 25 in the manual (control) group and 27 in the automated (treatment) group.

Experimental Design

The selected research method was a hybrid arrangement of the pretest-posttest control group design and the posttest-only control design depicted in Table 6.

TABLE 6

EXPERIMENTAL DESIGN

Random Selection **R**	Observation #1 $\mathbf{O_1}$	*Treatment* ***X***	*Observation #2* $\boldsymbol{O_2}$
Random Selection **R**	Observation #1 $\mathbf{O_1}$	*No Treatment*	*Observation #2* $\boldsymbol{O_2}$

The treatment group used the computer-based planning tool while the control group conducted training planning using manual planning procedures. The treatment and the non-treatment subjects developed a training plan in accordance with a practical exercise designed for the study. All subjects participated in all aspects of the experiment. The selected research pretest-posttest control group design proposed by Gibson,

Ivancevich, and Donnelly (1994) is "one of the simplest forms of true experimentation used in the study of human behavior" (p. 736). However, only the Adjusted Ratio of Clustering (ARC) dependent variable proposed by Gerjouy and Spitz (1966) required a pretest and posttest to determine the change in mental model development. To avoid interaction effects, Sproull (1995) asserts that "pretests are not necessary when random assignment is used" (p. 145). The other dependent variables were measured after the experiment or in phases consisting of a set of tasks. Consequently, the actual experimental design was a combination of the pretest-posttest and posttest-only control group model; hereafter referred to as the hybrid control group design.

Five experimental design issues considered for the experiment were:

1. history,
2. maturation,
3. homogeneity,
4. error variance, and
5. generalization.

The initial two research design factors are history and maturation. For experimental design, Kellinger (1986) argues that these are the two most significant factors related to time. History represents the time duration of the experiment, while maturation captures the learning which occurs during the experiment. The longer the

period between the pretest and posttest, the greater the chance that these two factors would affect the study (Kellinger, 1986). For this study, the history, or time between pre-test and post-test, was approximately one day for each subject. The short duration of the experiment did not require a need to investigate the maturity effects. Therefore, it is suggested that history and maturation may not have contributed to overall results due to the relatively short duration of the experiment.

A third research design consideration involves eliminating undesirable variables from the experiment. Homogeneity is one method for ensuring uniformity of variables, but there are unknown influences which are not easily identified and can cause unwanted variance (Kellinger, 1986). The best way for controlling extraneous variance is to randomly assign subjects to experimental groups and conditions, as well as, randomly assign conditions and other factors to experimental groups (Kellinger, 1986). However, the only factor or condition which was allowed to vary was the use or nonuse of the TREDS computer-based planning tool. The experiment only allowed for randomly assigned subjects, not conditions. The single condition and random assignment to the one factor of use or nonuse of TREDS was used to promote homogeneity. Table 7 shows the homogeneity of the two groups. Using a one-sample t test of individual data within the two groups, overlapping confidence intervals signify that there was no significant differences between the groups in four demographic areas. The conclusion is that homogeneity appears to be present among the two groups in the areas noted on Table 7.

TABLE 7

HOMOGENEITY OF GROUPS

Variable	Group	N	**Mean**	**StdDev**	**95% Confidence Interval**
Relative PC	Automated	54	3.259	0.851	(3.027, 3.492)
experience	Manual	50	2.860	1.088	(2.551, 3.169)
Years of PC	Automated	54	3.593	1.281	(3.243, 3.942)
Experience	Manual	50	3.200	1.457	(2.786, 3.614)
Frequency of	Automated	54	3.000	1.116	(2.695, 3.305)
PC Use	Manual	50	2.730	1.166	(2.399, 3.061)
Training	Automated	53*	2.321	1.010	(2.042, 2.599)
Experience	Manual	49*	2.286	0.866	(2.037, 2.535)
Simulation	Automated	53*	2.925	1.158	(2.605, 3.244)
Experience	Manual	50	2.740	1.139	(2.416, 3.064)

* Some of the data fields were not completed by the subjects

The fourth factor for good research design is minimization of error variance or variations which randomly fluctuate and balance out to zero (Kellinger, 1986). Individual differences among subjects cause error variance, while errors of measurement normally occur due to "variation of responses from trial to trial, guessing, momentary inattention, slight temporary fatigue and lapses of memory, transient emotional states of subjects, and so on" (Kellinger, 1986). The solution proposed by Kellinger (1986) is to control the

experimental conditions and insure good reliability by accurately assessing measures of effectiveness or scores. A large error variance caused by uncontrolled measurement errors will mask systematic variance which attempts to reveal the difference between the means. To assist in reducing all control errors, the researcher briefed and supervised the subjects on the testing conditions and the design methodology.

For external validity of data, representativeness or the generalization of results to relate to a specified population must be made (Kellinger, 1986). The samples should represent their population while the experimental environment and variables examined must be realistic and true to the purpose of the study and its conclusions (Kellinger, 1986). To satisfy the need for generalization, the study's experiment was conducted with a majority of personnel who possessed an average amount of training experience and were familiar with simulations. Table 7 shows the amount of training experience between the two groups was not significantly different at 5% level of significance. The apportionment of computer experience abilities between the manual and automated planning system subjects based on statistical tests indicates that the subjects in both groups were similar. The training experience of the personnel involved was not the only factor considered for analysis. Since subject teams were required to plan for and execute a computer simulation, simulation experience was a factor in assessing the team's ability to plan for simulation-based training. Table 7 shows that the simulation experience of the subjects varied evenly for both groups. This suggests that the two groups contained similar team profiles with regards to using simulations. The simulation experiences or

familiarity of the subject teams therefore had little effect on differences between each group's results.

Not only does the research need to randomly assign subjects to experimental groups and conditions, but the power of the experiment needs to be at a certain level (Kellinger, 1986). The power refers to the ability of the statistical test to significantly detect actual differences in means or actual improvements due to a training planning tool (Kellinger, 1986). Based on the personnel and resources available, the experimental objective initially was a sample size of at least 30 teams per group. This objective sought to obtain sufficient power for discerning differences among the responses.

The final design consideration involved the issue of generalization. The ability of using a sample group's experimental results for application to the population is generalization. The test audience results could be applied to the population at large, as long as, the same experimental design is used. Since a pretest could cause either the control or experimental group to become sensitized to the experiment and strive to do better, it is important to conduct the test with the pretest. The result could be a lack of generalization for applying the experimental hypothesis only to pretested groups versus the population at large as originally intended (Kellinger, 1986).

The five issues presented include some matters of concern which had to be addressed. All of these factors were heeded to ensure the study's experimental design yielded significant and consistent results. To review how TREDS relates to the experiment, the development of this treatment is now examined.

TREDS Development

The Training Exercise Development System (TREDS), a computer-based planning tool, was built from the synthesis of mental models of several expert planners. To support the development of a tool to automate planning for simulation-based training, subject matter experts (SME) were polled for descriptions of the training plan development process. In addition to SME interviews, process information and data were gathered from informal and formal conferences, training group meetings and demonstrations of initial TREDS prototypes. The experts' conceptual models of the training planning development process and other collected design parameters were then synthesized into the final system design for TREDS. The ultimate goal of this effort was to construct an automated tool which could support novice planners in developing their own mental model of the training plan development process and training plans.

An experienced training SME assisted the author and Dr. Kent Williams in building the TREDS model with cognitive tasks and rules. This process utilized the Cognitive Analysis Tool© developed by Dr. Kent Williams at the University of Central Florida as a means to organize production rules for mental representation of processes (see Appendix E for the rules). The resultant TREDS model was programmed using the FoxPro database in a Microsoft Windows© environment which applies object linking and dynamic data exchange for transfer of data. The TREDS program runs on a personal computer with at least eight megabytes of random access memory, 200 megabytes of free hard drive memory, Windows for Workgroups© vs. 3.11 and at least a 80486/50

megahertz computer processing unit. The modular structure of the planning tool with its training plan development components is depicted in Table 8.

TABLE 8

COGNITIVE ANALYTICAL MODEL OF TREDS

Events	*Tasks*	*Scenarios*
Record Mission Essential Task List	Assess Training Proficiency	Select Training Conditions
Build Calendars and Schedules	Prioritize Tasks	Select Scenarios
	Allocate Tasks to Events	Edit Scenarios
		Check Training Aids Devices, Simulators and Simulations Constraints
		Build Input Files and Exercise Products
		Capture Assessments

The structure and components of the initial TREDS model were subsequently compared with the Training Value System (TVS) proposed by Fitz-enz (1994). The TVS model, outlined in Appendix F, served as a basis to enhance the main components of the TREDS model. Cognitive conceptual models are concerned with how a person

represents information. The mental model presents the information and methodology in a logical manner for novices to use the expert's planning process with minimal training time.

Representing the expert's mental model of the planning process for simulation-based training, the TREDS planning tool was then ready to be applied to a military training context. For other domains, the TREDS tool can be tailored to the applicable training needs, audiences, priorities and characteristics. The development of a training planning process incorporates critical elements from several domains which use training simulations. These simulation systems are built for the end-users or trainers to improve their crews and overall organizational training postures.

The TREDS planning tool was designed as a bridge to connect training planning with the simulation-based training. The simulation itself may still be a "black box," but the inputs and outputs are articulated and organized through TREDS to enhance the training experience. Once the research design is established, the next step is the collection of experimental data.

Data Collection

For instrumentation of the experiment, data were collected to determine the pretest-posttest adjusted ratio of clustering (ARC) values from the free recall supported with feedback from the position memory tests. The posttest-only phase of the experiment consisted of data on quality ratings (Cooper & Harper, 1969), simulation measures of

effectiveness (MOE) (U.S. Department of Defense, 1993), task load index (TLX) scores (Hart & Staveland, 1988), and performance times. To measure background information and solicit post-test feedback on structured questionnaires, the author developed surveys similar to those used by Stout (1994). Dr. Kathy Quinkert at the Army Research Institute, Fort Knox, Kentucky, assisted the author in modifying the questionnaires to meet the study's objectives.

Prior to the experiments at both Fort Knox and Fort Hood, a pilot test in Orlando served to organize and formulate the experiment. For the pilot test, two groups of eight subjects who were learning to use training simulations volunteered to assist for extra credit in a military science course at the University of Central Florida (UCF). The pilot test provided confirmation and areas for improvement on the questionnaires and data collection forms. The pilot test results identified potential experimental setup deficiencies, enabling improved experimental organization.

One additional requirement had to be met before testing could begin. The battalion commander at Fort Knox requested that all testing material be approved by the U.S. Army Research Institute's field office at Fort Knox prior to the experiment. Dr. Kathy Quinkert provided meaningful feedback to improve the surveys and experimental layout. As a result of this process, approval was granted to conduct testing in May 1995 at Fort Knox.

The testing period at both locations (Fort Knox and Fort Hood) required one week each. Two-person teams were composed of a training planning officer and sergeant. At

Fort Knox (Location #1) 16 automated and 15 manual two-person planning teams were tested while Fort Hood (Location #2) involved 11 automated and 10 manual two-person planning teams. The total number of teams were 27 automated and 25 manual planning. Each team was not released until their experimental data were collected.

Dependent Variables

Dependent variables were selected to measure the effectiveness and efficiency of the responses incurred by the planning tool treatment. The following dependent variables are discussed with regard to their relationship to the study's sub-hypotheses (or hypothesis points):

1. *Adjusted Ratio of Clustering (ARC)*: a measure of the ability of the subjects to organize key information and knowledge requirements in the training plan development process for simulation-based training; values were between -1.0 and +1.0 (posttest-pretest) (Gerjouy & Spitz, 1966).

2. *Quality Rating Scores (QRS)*: the overall quality or effectiveness of the tool to assist in conducting planning for simulation-based training; measure used integer rating values ranging from one (the best) to ten (posttest only) (Cooper & Harper, 1969).

3. *Measure of Effectiveness (MOE)*: the simulation results are integers based on the number of systems varying in size from one to 50 and are used to evaluate the effectiveness of the team-developed simulation-based training plan (posttest only) (U.S. Department of Defense, 1993).

4. *Task Load Index (TLX) scores*: the workload measures ranged between zero and 100 to evaluate the workload efficiency of the planning method in each of the four phases of the experiment (posttest only) (Hart & Staveland, 1988).

5. *Performance Times*: temporal assessment of efficiency (measured in minutes) for conducting the required tasks for training planning development of simulation-based training (posttest only).

One goal of the experiment was to measure the ability to improve the planner's mental image of the training plan development process. Using free recall and position memory techniques, the experimental procedure was designed to allow the author to investigate the ability of the automated planning tool to convey an expert's mental model of the training plan development process for simulation-based training. The generalization that all computer-based planning tools enhance simulation-based training is predicated on the idea that the tool's underlying structure is similar to the expert's mental model of the training planning process.

Adjusted Ratio of Clustering Values

The first part of the experiment's hypothesis evaluated the improvement of the user's mental model through the use of a computer-based planning tool. Testing the study's mental model hypothesis involved capturing the mental model of the training planner before and after using a computer-based planning program or current manual planning method. Since spatial ability is a key component of assessing an individual's capability to diagram the training plan development process, a surface development cognitive test by Ekstrom, French, Harman, and Dermen (1976) tested this factor. Using the 't' test, the results showed that there were no significant differences between individuals in the automated and manual groups ($p > 0.05$). The 95% confidence

intervals for the spatial test scores are between 17.40 and 41.55 for the manual group and between 20.63 and 35.40 for the automated group. Since the confidence intervals overlap, there is no significant differences in the two groups' spatial abilities.

The cognitive psychology tests for free recall and position memory were used to evaluate the individual mental model improvement by both groups. These tests have been used for psychological experiments involving memory recall of lists (telephone interview with Dr. James Nairne, January 1995). Stanney and Salvendy (1994) also used clustering in free recall procedures "to examine how structuring demands influence memory knowledge structures and computer performance of Field Dependent (FD) individuals" (p. 602). The free recall and position memory methods provided quantitative results. These data are measures to assess whether the planning method improves the user's mental model of the training plan development system.

The free recall survey requires that the subject describe the training planning process. The clustering of key terms around the conceptual information model for training plan development are compared with the subject matter expert's (SME) mental model depicted in Table 8. Gerjouy and Spitz (1966) introduced the Adjusted Ratio of Clustering (ARC) for quantifying a subject's ability to remember categorical items in memory recall. Stanney and Salvendy (1994) state that "clustering is thus seen as a consequence of organization in memory of the target information" (p. 602). For the experiment, the knowledge of the training planners is the result of memory organization.

In position memory tests, a similar approach provides measures to check the congruency between the categorization of key terms in the training plan development model (Table 8). Nairne (1991) provides additional guidance and examples which describe how to measure position memory recall abilities. For this experiment, the free recall and position memory forms are in Appendix G, while the ARC values for free recall are in Appendix H. The position memory data (in Appendix I) were used to support the free recall results and conclusions.

Quality Ratings

A method developed by Cooper and Harper (1969) for measuring pilot aircraft ratings was also used as a means to gather objective scores on qualitative attributes based on human judgment (Werewinke, 1974). According to White (1994), the "Cooper-Harper Handling Qualities Rating (HQR) provides a subjective measure of aircraft handling qualities and piloting workload which takes into account the task performance and any pilot compensation required to achieve it" (p. 6-6). Instead of aircraft handling, the form was modified to ascertain the handling characteristics or effectiveness of the planning method, manual or automated. The resultant dependent variable was a subjective rating of the effectiveness of the automated planning process versus the manual process.

Applying the same rating convention as Cooper and Harper, the study's quality rating varied from one to ten, with one indicating that the handling quality of the program

is satisfactory. Higher values show less effective methods with increased workload and substandard performance. Appendix J shows the quality rating form modified for this study. Appendix K contains the quality rating experimental data.

Measures of Effectiveness.

For a simulation exercise, the measures of effectiveness (MOE) identify the efficiency or performance gains of a training program. Simulation data are converted directly or transformed through a combination of output variables to build measures of certain aspects of the training plan, such as, survivability and lethality. The Janus simulation provides output data for quantifying survivability and lethality data, such as, the number of combat systems which were destroyed in a simulation run. This research will apply MOE to evaluate the effectiveness of the computer-based planning tool to create a plan replicating a realistic scenario for a military combat team simulation training exercise. The MOE are defined in Appendix L and the data which were used to assess training plan effectiveness are in Appendix M.

Task Load Index Scores

The Task Load Index (TLX) is a multidimensional rating scale procedure that measures changes in operator workload levels for different sets of tasks (Hart & Staveland, 1988). The overall workload scores include six bipolar dimensional ratings of mental demands, physical demands, temporal demands, performance, effort, and frustration. This methodology was developed through extensive research and

psychometric analyses in laboratory experiments and simulated flight experiments conducted by Hart and her research partners (Nygren, 1991).

Hart and Staveland (1988) state that the purpose of their research was to develop a workload rating scale that provides a sensitive summary of workload variations within and between tasks that is diagnostic with respect to the sources of workload and relatively insensitive to individual differences. Nygren (1991) concludes that the TLX method is very beneficial and robust in measuring perceived workload in many environments. To obtain a quantitative measurement of the workload for TREDS tasks in this experiment, the TLX scores were appropriate. The TLX scores measured the effectiveness of the two planning methods. The forms are shown in Appendix N and data are included in Appendix O.

Performance Times

The performance time for a set of tasks was recorded (to the nearest minute) to measure whether or not the experimental group conducted the experiment faster. The times were measured in four incremental phases of the experiment where it was necessary to begin another more unique set of tasks (form in Appendix P). The resultant times for each phase were compared as team statistics (see Appendix Q).

Questionnaires

To augment the research data for in-depth analysis, verbal and written reports assist in measuring efficiency and effectiveness that is not captured through empirical

evidence (Rouse, Cannon-Bowers, & Salas, 1992). Structured questionnaires were used to gather background subject information on areas such as, military training experience, computer experience and simulation experience (see Appendix R). Open-ended response questions were used to solicit experimental feedback and assessment of the planning methods (see Appendix S).

Test Procedure

Anderson (1987) suggests that once the mental mechanisms which implement a task are computer-based, the next step is to estimate parameters of its implementation for the purpose of proving assumptions of the model's utility. A practical exercise was used to enable replication of the tasks for users to conduct the training planning process, either manually or computer-based. The main tasks are as follows with more detailed objectives described in the Practical Exercise packet (Appendix D):

1. Solicit demographic information from subjects.

2. Request individual subjects to depict a mental model of the planning process for simulation-based training using free recall and position memory techniques.

3. Capture subject feedback through time sheets, task performance surveys and comparative evaluations during the training planning process conducted in the steps below:

    a. Conduct a task analysis for simulation-based training.

    b. Assess training proficiency and task prioritization.

c. Create and edit simulation-based training scenarios to build a training plan.

d. Evaluate and rehearse Janus simulation scenario using the developed plan.

e. Run the Janus simulation scenario.

f. Assess training proficiency based on Janus simulation results.

4. Repeat step #2.

5. Solicit verbal and written freeform feedback from subjects.

These steps enabled the collection of data and information representative of an actual training planning situation that leaders would normally encounter in conducting planning for simulation-based training.

Data Analysis

The data used for the experiment were collected using forms and questionnaires from related work in the fields of training, planning, simulation and cognitive psychology. The independent variable was the use or nonuse of the treatment tool, TREDS, while the dependent variables were the adjusted ratios of clustering (ARC), quality ratings, task load index (TLX) scores, performance times and measures of effectiveness. Additional background information obtained from the demographics and post-exercise questionnaires included:

1. computer and Microsoft Windows© operating system familiarity,

2. training, planning and simulation experience, and

3. self-assessment of knowledge increase.

Statistical Methods

In seeking the appropriate nonparametrical test for the comparison between the two independent and randomly selected groups, the Mann-Whitney test was chosen since it is "the usual parametric counterpart" for the two-sample *t* test (Conover, 1980). Additionally, the strength of the Mann-Whitney test is almost as strong as the parametric *t* test even if normality existed (Conover, 1980). In some cases, data could produce a distribution that is difficult to identify, as well as, curtail the number of data points. The unidentifiable data distribution also confirmed the rationale for using nonparametrical statistics.

The experimental data showed whether or not there is significant difference between the treated and the control groups. The use of TREDS is the treatment variable. If there were any significance noted by the nonparametrical test for each measure, then there is a difference between the group which used the computer-based planning training tool and the group which relied on manual/traditional training planning methods.

Summary

The methods and procedure for the experiment followed lab research testing practices. The subjects were two-person teams of U.S. Army training planners who had

volunteered their time to test the hypothesis of computer-based planning tools for simulations. The subjects at both test sites used the planning tools and Janus simulation as part of the experiment.

This experimental design focused on the use of data to show the difference between those who use and those who do not use a computer-based planning tool. The control group design facilitated gathering information on both mental model achievement and comparison of the two methods for planning. The study's objective was to assess the hypothesis that computer-based planning tools enhance the effectiveness and efficiency of the Janus simulation-based training. The next chapter discusses and analyzes the results collected from the research methodology and design.

CHAPTER 4

DATA ANALYSIS

This chapter provides the analysis of the data for the study. Analysis was based on data collected from 25 manual and 27 computer-based planning teams. The response measures affected by the independent variable were the adjusted ratio of clustering (ARC) values, quality ratings, simulation measures of effectiveness (MOE), task load index (TLX) scores, and performance times. Demographic information and post-exercise feedback aided the interpretation of the statistical results.

The study's pretest-posttest data were analyzed using the Wilcoxon signed ranks test, while the Mann-Whitney test was used for assessing the other four response variables. Histograms also depict the frequency distributions of the data. The demographics and post-experiment questionnaires provided insights on the subjects' assessments of the planning tools.

According to Sproull (1995), "the most commonly used significance level is .05" (p. 59). This study seeks to minimize the risk of overstating its assertions since the research is important to the body of knowledge and represents doctoral-level research. Thus, the level of significance for all of the tests was set at 5%. The results will now be discussed in more detail as to determine the proof of the hypothesis at a level of 5%.

Mental Model Measurements

Hypothesis Point #1: *A computer-based planning tool will enhance the mental model of the training plan development process.* The first point of the hypothesis was tested using the Wilcoxon signed-ranks test. This test compared the pretest-posttest results for both groups. The free recall results indicate that a computer-based planning tool does improve training planning (Appendix I).

Initial analysis of the experiment revealed a large variance in both the pretest and the posttest data for the ARC values. A large index of variation (IV) ratio[1] implies that the mean would not be a good estimation of the true average of the population (Kan, 1995).

TABLE 9

ARC VALUES FOR IV COMPARISON

	Pretest		**Posttest**	
Measure	*Manual*	*Computer-based*	*Manual*	*Computer-based*
Mean	-0.12	-0.16	-0.02	0.10
StDev	0.35	0.33	0.29	0.41
IV	2.36	3.35*	13.82*	2.25

* Index of Variation exceeds 3.0;indicates that variance is too large and sample size should be larger

[1] The formula for the index of variation is (standard deviation) / (mean).

Table 9 presents the IV ratios to illustrate the magnitude of the standard deviation versus the mean. The standard deviations are exceedingly higher than their respective means. There is too much variance to conduct parametric statistics on. Additionally, the plotting of a stem-and-leaf diagram revealed that the data may not be normally distributed. Figures 2 and 3 also indicate such a trend in the ARC values. According to Milton and Arnold (1986), the results of a chi-square test on data with large variances do not always validly show normality. Milton and Arnold assert that instead of using a possibly invalid assumption of normality, nonparametric methods are "usually superior for analyzing data when the normal theory assumptions are not met; they compare very favorably to the normal theory test even when the normal theory assumptions are met" (p. 242). Therefore, the safest statistical method, a nonparametric test, will be used throughout this study to take advantage of this situation in case there is not enough normality in the data.

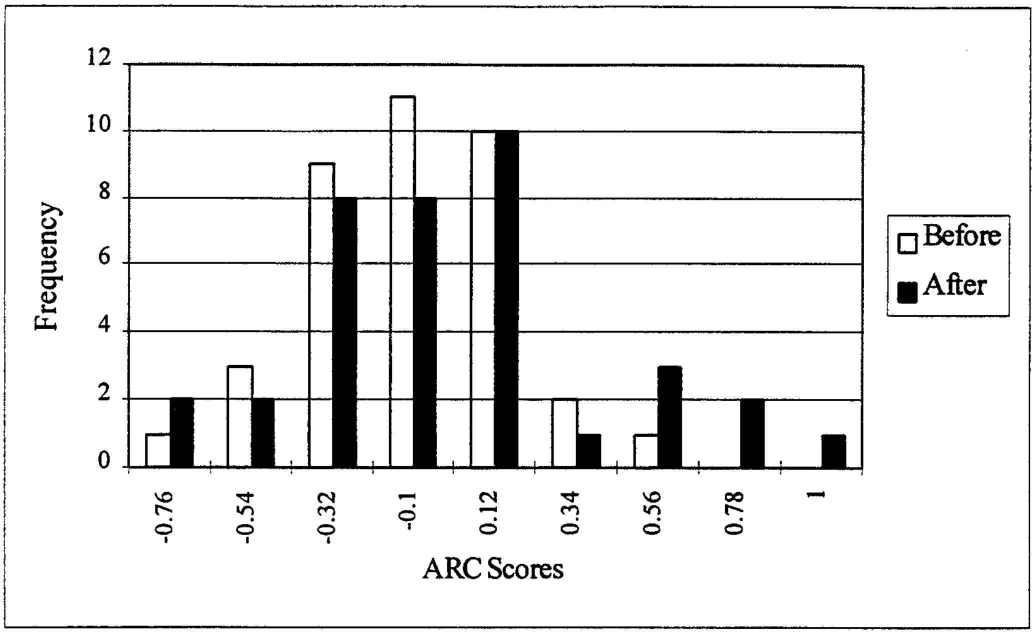


Figure 2. ARC Value Test Results for the Manual Group

Figure 2 shows the ARC values for the manual groups on both the pretests and the posttests. The manual planning teams did not appear to show any significant gains in the subjects' mental models of the training planning process. Noting the missing data on the right-side of the graph in Figure 2, one can observe that none of the manual subjects maximized the score on the pretest. The manual group did have one subject who was able to maximize the posttest.

Figure 3 also portrays that the ARC test results imply the potential of improved mental models for the computer-based planning groups between the pretest and the posttest. In reference to some of the apparent missing data on the graph in Figure 3, none of the automated subjects maximized the pretest or posttest, while there were also no scores of 0.78 in the prettest results.

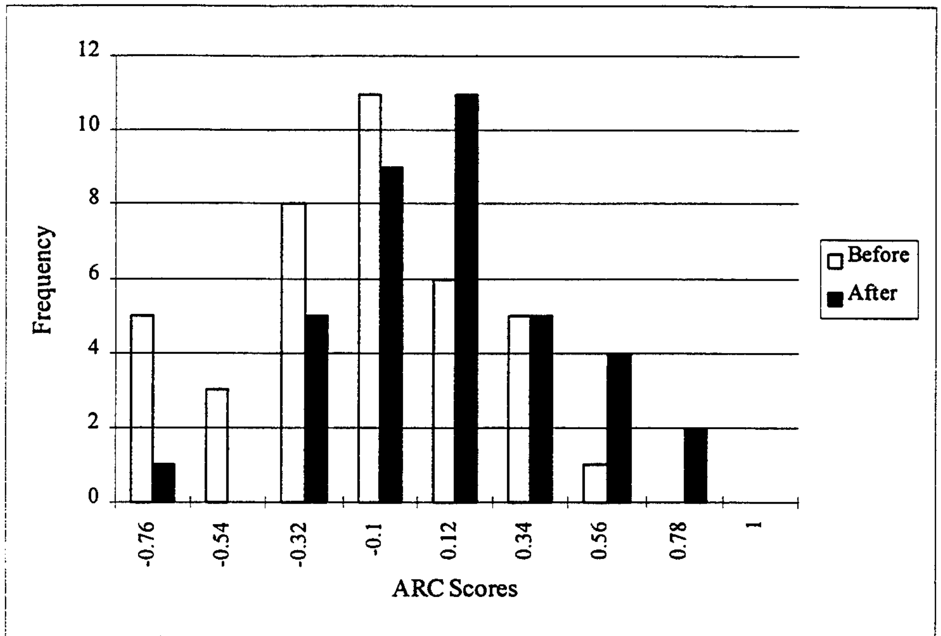


Figure 3. ARC Value Test Results for the Automated Group

For statistical analysis, the Wilcoxon signed-ranks test was used since the pretest and posttest ARC values were related variables (see Table 10). At the significance level of 5% for the computer-based planning team subjects showed that they gained a significant increase in the understanding of the training planning conceptual model. The confidence intervals between the two tests did not overlap, showing there is significant difference between the pretest and the posttest scores for the automated group. However, the changes in ARC values from pretest to posttest for the manual group subjects were insignificant ($p > 0.05$) (Table 10).

TABLE 10

PRETEST VS. POSTTEST ARC VALUES

Variable	$Median_{after}$ - $Median_{before}$	P-value	Significance
Manual	.00	0.362	$p > .05$
Automated	.22	0.001	$p < .05$

The results of the pretest-posttest data on free recall suggest that the computer-based planning tool did improve the mental model of the computer-based team members, while there was no significant change in mental models for the manual teams. A computer-based planning tool will enhance the mental model of the training plan development process with a probability greater than 95% For hypothesis point #1, the mental model of the automated teams improved at the 5% level of significance. A similar statistical test using the position memory data (in Appendix I) also revealed that the automated teams improved their mental models ($p < 0.032$) while the manual teams did not ($p < 0.965$).

To examine whether there was a difference between the mental models of the two groups, the nonparametric Mann-Whitney test was conducted with results shown in Table 11. The first line of Table 11 divulges that the pretest ARC values were not significantly different for both groups, implying that both groups started the exercise with similar mental models. For the free recall posttest data results, however, the computer-based teams showed significantly improved mental models than the manual planning teams had

($p < 0.0389$). Analysis of the position memory data (in Appendix I) also refuted the free recall results by showing that the automated teams' mental models were not significantly more accurate in the posttest results ($p<0.711$) versus those of the manual teams. This result implies that the position memory may not be accurate for the measurement of mental model recall. The essential measure of this point in the hypothesis though is the free recall ARC value results.

TABLE 11

ARC VALUES BY PRETEST-POSTTEST

Variable	Median_{auto} - Median_{man}	P-value	Significance
ARC value Pretest	.00	0.3449	$p > .05$
ARC value PostTest	.22	0.0389	$p < .05$

Results were significantly better for the automated planners than for those who applied manual planning procedures. These free recall results confirm the hypothesis that the automated planning tool enhanced the mental model of subjects who used the computer-based planning tool. Combined with the pretest-posttest analysis already conducted, the hypothesis point #1 is further supported at the 5% level of significance. Therefore, the data show that the computer-based planning subjects improved their mental models of the training plan development process.

Using the pretest-posttest design, it was confirmed that the TREDS computer-based planning tool enhances the effectiveness of planning for simulation-based training

by improving the user's mental model of the training planning process. The next point of the hypothesis concerns the effectiveness of simulation-based training plans created by automated planning tools.

Effectiveness Measurements

Hypothesis Point #2: *More effective training plans are created and results achieved with computer-based planning tools.* The two dependent variables used to test for significance of the second point of the hypothesis are quality ratings and simulation measures of effectiveness (MOE).

Quality Ratings

The purpose of the quality ratings was to gain user feedback in quantitative terms on the ability of the planning method to assist the subject in building effective training plans. Quality ratings were elicited in integers from one (the best) to ten. The quality rating results were significantly better for the automated group than for the manual group (see Figure 4).

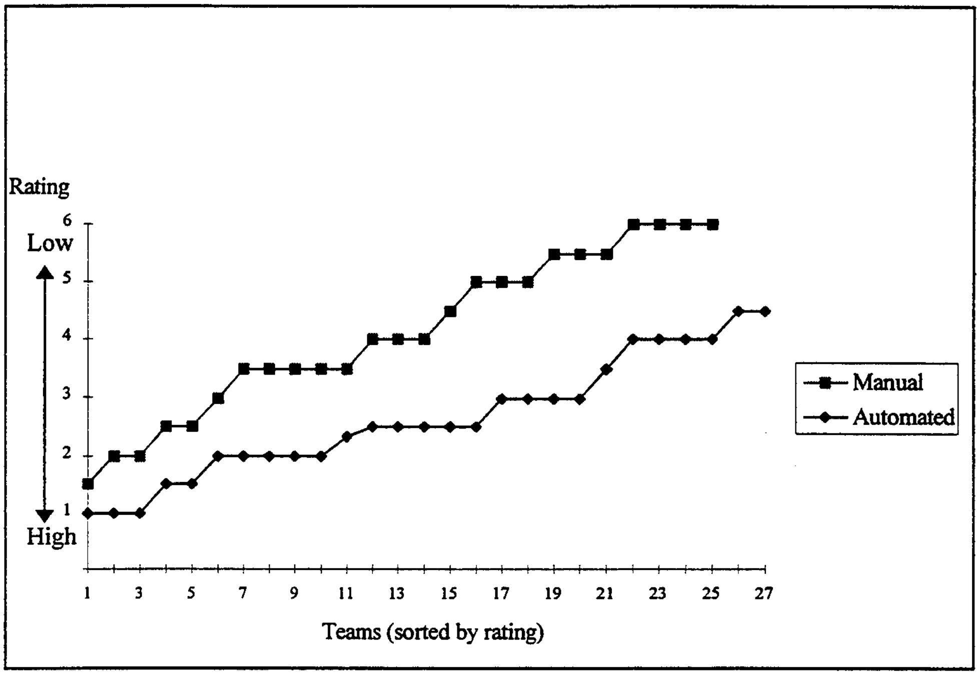


Figure 4. Planning Tool Quality Ratings

To determine whether there was a significant difference between the groups as suggested by Figure 4, a Mann-Whitney nonparametric *t* test was conducted. The results of the nonparametric test on the posttest-only control group design are depicted in Table 12 (quality rating data is in Appendix K).

TABLE 12

QUALITY RATING STATISTICS

Median_{auto} - Median_{man}	P-value	Significance
-1.5	0.0002	$p < .05$

The quality rating data were analyzed to determine whether the computer-based teams considered the training planning process more effective than the manual teams did. The median team Quality Rating scores on a scale of one to ten (with one being the highest) was 4.0 for the manual group while the computer-based group had a median score of 2.5. The means and standard deviations (stdev) of the Quality Rating scores for the manual and the automated teams were ($mean_{manual} = 4.120$, $stdev_{manual} = 1.394$) and ($mean_{automated} = 2.642$, $stdev_{automated} = 1.047$). The quality rating results significantly show that the computer-based planning tool was easier to use and more effective in planning training than the manual method.

The quality rating scores for conducting the training planning were measured to ascertain whether the effectiveness of the planning method enabled the subjects to perform their goals with ease. Hypothesis point #2 also sought to test effectiveness by examining the simulation's outcome attained by the teams' training plans.

Simulation Measures of Effectiveness

To assist in measuring training plan effectiveness for the posttest-only control group design, the simulation measures of effectiveness (MOE) were collected. Analysis of the MOE for the simulation runs sought to determine the difference between the data from the training plans that each team developed for the Janus training simulation.

Two standard military MOE are the number of friendly forces who survive (often focusing on critical military vehicles such as tanks) and the number of enemy forces

destroyed (see Table 13). These two measures assist in determining whether an iteration of a battle simulation is successful. For civilian emergency management simulations these MOE may be similar, for example, with regard to the number of human lives saved and amount of property damaged.

TABLE 13

SIMULATION MOE

MOE #1	**MOE #2**	**MOE #3**
# Tanks surviving	# Infantry Vehicles surviving	# Enemy Forces Destroyed

For the data on the number of friendly forces which survived the battle (survivability), there were no significant differences. At a significance level of 10.36%, the manual group had more infantry vehicles remaining. This value does not meet the significance level of 5%. The lethality MOE which showed number of enemy forces destroyed by the teams was MOE #3. From the graphical comparison between the manual and automated teams, it appears that the results are similar (see Figure 5). There was no significance between the two groups in terms of the lethality MOE results ($p > 0.05$).

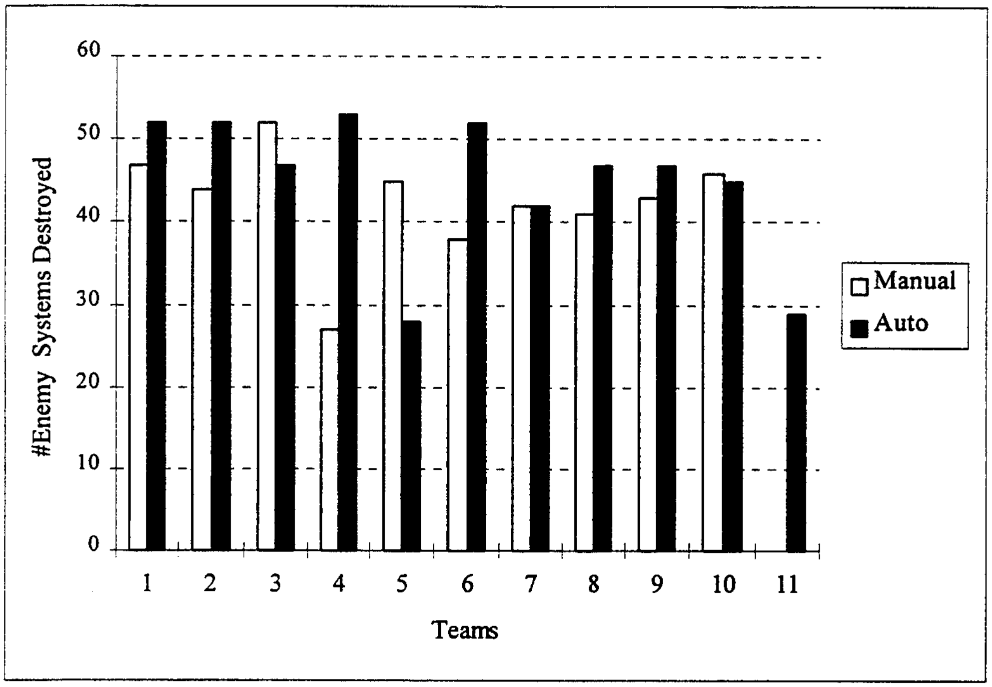


Figure 5. Simulation MOE #3 Results

To test the hypothesis for effectiveness, the Mann-Whitney test was conducted. Measure of effectiveness #3 was not significant at 9.6% for the computer-based group with a median of 44 enemy ground forces destroyed for the manual group versus 47 enemy ground forces destroyed by the computer-based group (see Table 14). The means and standard deviations are ($mean_{manual}$ = 43.00, $stdev_{manual}$ = 6.82) and ($mean_{automated}$ = 44.91, $stdev_{automated}$ = 8.81).

TABLE 14

SIMULATION MOE #3 STATISTICS

Variable	Median_{auto} - Median_{man}	P-value
Sim. MOE #3	3	0.096

The survivability and lethality MOE appear to be contradictory even though there is no significant difference between the results for the two groups. It could be possible that the teams which lost more systems were bolder and engaged in heavier fighting, thus incurring more enemy losses. Further testing using other MOE may dissolve the apparent presence of interaction effects between the two MOE variables.

Since only one of the two measures for effectiveness showed significant differences at the 5% level, the hypothesis point concerning the ability of computer-based planning tools to improve the effectiveness of simulation-based training is not sufficiently proven. These results imply that there may not be a correlation between the training plan development method and the results of the simulation scenario. Additional research in the testing of simulation plans is needed to justify further use of this variable as one which is affected by the planning method.

Efficiency Measurements

In addition to the effectiveness of assisting the user in understanding the system, the time and workload efficiency of the training planning development process is also

important. The third point of the hypothesis states that simulation-based training planning is more efficiently accomplished using computer-based tools.

To measure efficiency for the posttest-only control group design, Task Load Index (TLX) scores and performance time measures were collected. Both variables required measurements throughout the experiment. The experiment was divided into four sessions as follows:

1. task identification and prioritization,
2. training plan development,
3. simulation rehearsal and execution, and
4. performance assessment.

To test this the efficiency point of the study's hypothesis, the Task Load Index (TLX) results were examined to show whether workload was reduced for computer-based planning of simulation-based training.

Task Load Index Scores

This dependent variable sought to test whether computer-based tools reduce the workload of planning for simulation-based training to make the training planner's ability to plan more effectively. The TLX scores for conducting the training planning (see Figure 6) were measured to ascertain whether the difficulty of each set of tasks was reduced using the manual method or the computer-based planning tool.

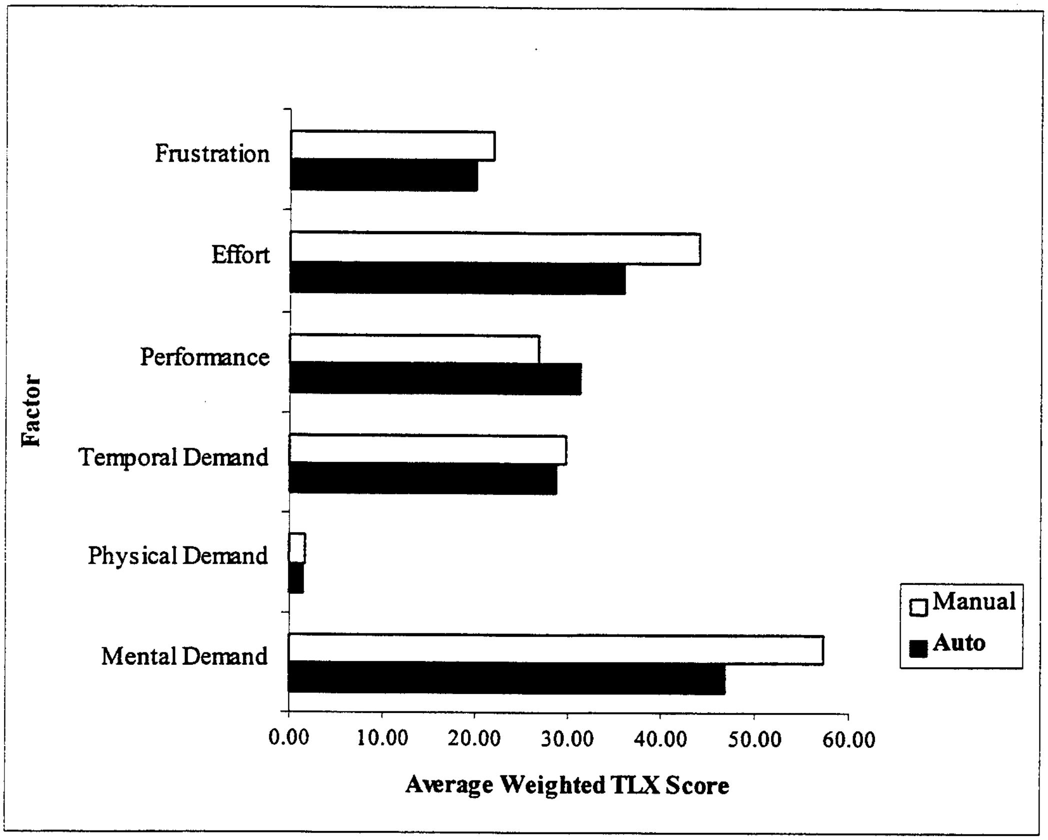


Figure 6. Task Load Index Scores by Factor

Figure 6 presents the factors involved in the TLX procedure. First, the overall effects and statistics of the total TLX score will be examined. Using the Mann-Whitney statistics (Table 15), the TLX scores were assessed for significance as relating to efficiency. The median TLX score for the manual group was 184.08 while the computer-based group had a median score of 166.67 (lower is better). For the mean and standard deviation, the results were ($mean_{manual}$ = 183.54, $stdev_{manual}$ = 40.00) and ($mean_{automated}$ = 166.47, $stdev_{automated}$ =40.43). Using the Mann-Whitney nonparametric test, the first part of hypothesis point #3 is not confirmed at a level of 5%. The computer-based planning

TABLE 15

TLX SCORE STATISTICS

Variable	Median_{auto} - Median_{man}	P-value
TLX Score	-17.92	0.065
Mental Demand	-12.75	0.012*
Effort	-11.25	0.027*
Physical Demand	-1.0	> 0.05
Temporal Demand	1.5	0.043**
Frustration	-4.34	> 0.05
Performance	10.5	> 0.05

* Automated is significantly better at 5% ** Manual is significantly better at 5%

tool required the same workload and was thus not significantly different than the manual planning method in efficiency.

For overall efficiency testing, the sum of the six factor scores were used. Table 15 shows the results of the statistical tests on the hypothesis for improving the efficiency of simulation-based training planning. The Mann-Whitney statistical testing does not verify this point in that the overall difference between the manual and computer-based

groups' perception of the workloads was not reflected in their respective planning processes.

The bipolar factor results in Figure 6 suggest that certain factors may be more important than others. Three TLX bipolar factors showed significant differences between the manual and computer-based groups. For Mental Demand, the level of significance was 1.2% showing that the computer-based group perceived a workload factor of mental demand 99% of the time to be easier than that experienced by the manual group. Effort was significant at a level of 2.7% for the teams using the computer-based tool versus the manual method. With the introduction of a new tool, the perceived temporal demand for the automated group was viewed as significantly higher for the automated planning tool users. These results are important in that they suggest that the computer-based planning reduces workload and eventually increases effectiveness as defined by Rouse (1991) in terms of making the difficult tasks less demanding. The temporal demand may be higher for the automated teams due to the pressures involved in trying to use the automated planning tool and still expect to finish the exercise in a reasonable period of time, perhaps in less time that the manual teams.

As part of the TLX process to calculate the scores, all subjects were asked to conduct pairwise weightings of the six dimensions used on the TLX worksheet. The significant results, of mental demand and effort also emanated from two of the three highest weighted factors. From Figure 7, the significance of mental demand (25%) and

effort (21%) having predominant weights suggested that subjects considered these factors more demanding in the experiment.

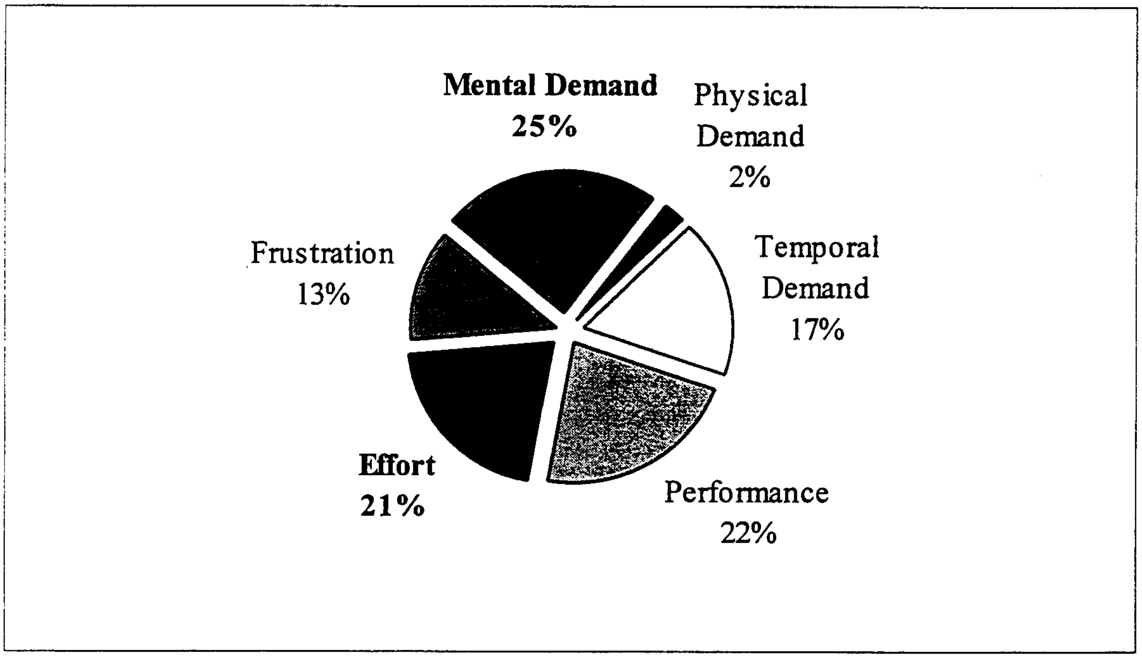


Figure 7. Weights for TLX Scoring

The mental demand and effort workload dimensions were significantly higher for the manual teams than for the automated teams. However, temporal demand, weighted at 17%, was perceived by the automated teams as being higher than that experienced by the manual teams (Table 15). The reason for such a result may be that the automated teams felt pressured by time, since they were working with a new planning tool. However, the effort and mental demand workloads were perceived as less by the automated teams. This could have resulted from the computer-based tool's ability to relieve the experimental teams from the tedious and mentally demanding tasks of training plan development. The TLX experimental results show some potential of the ability of a

computer-based planning tool to increase the workload efficiency of the subjects. An additional measure for assessing efficiency is the time required for conducting the tasks of the training planning experiment. The overall times were compared and analyzed to find the efficiency differences between the computer-based and manual groups.

Performance Times

The task performance times for conducting the training planning (see Table 16) were measured to evaluate the time required throughout the experiment. The entire experiment was divided into four separate sessions. The overall performance time required for the entire exercise was used as the dependent variable for both groups.

The Mann-Whitney statistical testing does not support the premise that the automated groups had lower times than those recorded for the manual planning group (see Table 16). The median time for the manual group was 250 minutes while the computer-based group had a median time of 224 minutes. The mean and standard deviations for time performance of the two groups are ($mean_{manual} = 272.2$, $stdev_{manual} = 80.5$) and ($mean_{automated} = 238.9$, $stdev_{automated} = 57.2$).

TABLE 16

PERFORMANCE TIME STATISTICS

$\mathbf{Median_{man}}$	$\mathbf{Median_{auto}}$	**P-value**
250	224	0.078

Applying the Mann-Whitney nonparametric statistical test, at a significance level of 5%, the hypothesis is not confirmed. There is no significant difference which shows that the computer-based planning tool required less time and was thus more efficient than the manual planning method. The overall time for training planning was not significantly different for the two groups. Considering that the computer-based teams were initially trying to learn how to use the computer-based tool, these results are promising, in that the automated planning teams were able to maintain the same speed as the manual teams in conducting the tasks.

At the level of significance of 5%, the third point of the hypothesis was not proven. The computer-based planning tool failed to show significant improvement in efficiency of training plan development for simulation-based training. A summary of the dependent measures for the hypothesis that computer-based planning tools enhance the effectiveness and efficiency of simulation-based training is provided in Table 17.

TABLE 17

SUMMARY OF SIGNIFICANCE FOR DEPENDENT VARIABLES

Variable	**Median_{auto} - Median_{man}**	**P-value***
Free Recall ARC value PostTest	.22	0.0389**
Quality Rating	-1.5	0.0002**
Sim. MOE #3	3	0.096
Performance Time	-23	0.078
TLX Score	-17.92	0.065

*Level of Significance is 5%; ** Significant at $p < 0.05$

In addition to the statistical results for proving the main hypothesis, the study gathered positive feedback regarding the use of computer-based planning tools.

User Feedback

As for the computer-based planning tool, feedback was very positive with exclamations on how essential a training planning tool is (see Appendix S). Some of the novice planners stated that they understood the training planning process better and appreciated the opportunity to learn about training and planning with simulations (see Table 18). Many subjects expressed the desire to have more time with the planning tool and the simulation.

TABLE 18

POST-EXERCISE FEEDBACK

What did users like about the TREDS planning tool?

Training	**Planning**	**Mental Models**	**Computer-based**
“It was good to be able to see what areas you need to train for each task and how to incorporate those tasks into training.”	“Determining weaknesses in my planning process, but also, able to see how the planning process can be effective.”	“The computer gave you a picture to work with. You could easily try different approaches quickly.”	“It was much more user friendly than trying to do it ‘stubby pencil’."
Overall comment:	“It's a good training tool; best I've seen in 19 years!”		

Overall, the majority of the subjects provided positive and useful feedback to improve the training planning tool. Prior to the experiment, most of the subjects had never seen or used a computer-based training planning tool. The initial demographics of each subject suggested that there were adequate levels of computer experience and Microsoft Windows© knowledge than originally anticipated by the experimenter. However, the feedback received after the testing was very informative in understanding the expectations and needs of the subjects.

User feedback accentuated the need for automated planning tools for simulation-based team training. Also, those subjects who had little experience with the Janus simulation provided positive feedback for the manner in which the automated planning tool helped them understand and use the simulation better. Many individuals, including those on the manual planning teams, were anxious to return for more simulation-based team training.

Summary

The results of the experiment encourage further research and development of computer-based planning tools for simulation-based training. The methods used to obtain viable results were instrumental in the experiment's success. By using appropriate and measurable criteria for the treatment effects, the study captured innovative and reliable methods to justify computer-based planning. Each measurement yielded information on the potential need for future research of computer-based planning tools.

The ability of the TREDS computer-based planning tool to improve the user's mental model of the training planning process shows knowledge improvements for novice planners. The results of the study did not show any significant mental model increase for the manual planning teams. Participation in the experiment did not seem to increase their understanding of the training planning process.

For this experiment, a quality rating form was used to gather feedback on the overall quality of the training planning method. The effectiveness of the planning tool is

essential to convince users to reuse the tool. The quality rating score was significant for showing the effectiveness of the overall training planning process. The simulation measures of effectiveness results supported the premise that the teams that used automated planning tool developed more effective training plans.

Finally, the measures of efficiency were evaluated to determine the utility of an automated planning tool to enhance simulation-based training. The TLX scores and performance time results showed significant improvement in the efficiency of computer-based teams in planning the essential tasks for simulation-based training. All three points of the hypothesis were not confirmed at the 5% level of significance, indicating that the use of computer-based planning tools does not enhance the effectiveness and efficiency of simulation-based training. This statement is somewhat contradicted by the positive user feedback gleaned after the experiment. The next chapter will conclude the study and recommend future courses of action to capitalize on the contributions of this research which warrant further examination of computer-based planning for simulation-based training.

CHAPTER 5

DISCUSSION AND RECOMMENDATION

The original contribution of the research conducted in this study is the partial validation of benefits derived from the use of computer-based planning tools to enhance the effectiveness and efficiency of simulation-based team training. Specifically, the study:

1. provides a methodology for investigating the use of computer-based planning tools to enhance the effectiveness and efficiency of simulation-based training,

2. identifies the linkage between training task requirements and simulation-based training characteristics by building a mental model of the training plan development process, and

3. assists future research efforts by providing potential measures of effectiveness and efficiency for evaluating technological advancements.

Discussion

The major question related to this study has been: *What contributions do computer-based planning tools offer to simulation-based team training?* This question is divided into three points:

1. Mental Model Measurement: Will a computer-based planning tool enhance the user's mental model of the training plan development process?

2. Measures of Training Effectiveness: Are more effective training plans created and better results achieved with computer-based planning tools?

3. Measures of Training Efficiency: Is simulation-based training planning more efficiently accomplished using computer-based tools?

Mental Model Measurement

Hypothesis Point #1: *A computer-based planning tool will enhance the mental model of the training plan development process.* Based on the results this hypothesis was supported. The use of cognitive-based training exercise development systems for planning simulation-based training has the potential to improve the understanding of generating training development plans. Other applications of computer-based planning tools for simulation-based team training could assist civilian and military agencies in planning and conducting disaster preparedness training, airline pilot exercises, and nuclear accident scenario drills.

The study has collected potential justification for the enhancement of simulation-based training planning by using a computer-based planning tool. The method to prove such a theory applied human cognition factors in the development of mental models. While the conceptual model of a system or process is likely to evolve, the users need to understand the structure of the process in order to foster an accurate mental model. This study has provided a means to determine the user's mental model for training planning and measure how effective that mental model has developed using free recall ARC values.

Measures of Training Effectiveness

Hypothesis Point #2: *More effective training plans are created and results achieved with computer-based planning tools.* This point was partially substantiated with the data from the quality ratings. The results of the simulation MOE do not show significant difference between the two groups at an alpha of 5%. The computer-based planning teams considered the utility of their tool to be of higher quality and thus more effective than the manual tool planning teams considered theirs. The capability of the computer-based planning tool to enable users to link training tasks objectives with the simulation-based training was achieved.

With respect to the simulation exercise, the computer-based planner's measures of effectiveness for the survivability of friendly systems or destruction of enemy systems was not significantly higher than those for the manual planners. Based on significant results with only the quality ratings results, these results cannot affirm that a computer-based planning tool creates more effective training plans for improved simulation results.

Measures of Efficiency

Hypothesis point #3: *Simulation-based training planning is more efficiently accomplished using computer-based tools.* First of all, the Task Load Index (TLX) results show that the computer-based planning tool did not decrease or increase the perceived overall workload for the treatment group. Specifically, mental demand and effort were the two factors that the computer-based planning group reported as

significantly easier than that experienced by the manual planning group. However, the manual planning teams perceived that the temporal demands of their methods were less than those reported by the automated tool. This could have occurred due to the time that the automated users needed in order to become familiar with the computer-based planning tool.

For overall performance time, there were no significant differences between the two groups at a level of significance of 5%. The times between the two locations showed a large increase in time because of the availability of full-time simulation center instructors at the second location (Fort Hood). Finally, one of the key objectives for computer-based planning tools, as also for the TREDS program, is to save time for team planners. Once the users improve their use of the TREDS program in its Microsoft Windows© environment, the training planning time for automated planners could decrease further with an increased understanding of the peripheral TREDS programs and its operating system.

Investment for simulations is costly in terms of time and manpower. Thus, the need to ensure their full utilization is very critical to ensure effective and efficient user implementation and training benefits. Delivering effective training at a significantly reduced cost is becoming a priority for planners and trainees. The potential of TREDS for meeting the needs of those involved in the complexities of the simulation-based training planning process has been indicated, but not significantly proven through the analysis of the hypothesis' components. The results did confirm that automated planning

tools significantly aid the user's understanding of the conceptual training plan development processthan the manual planning methods do. Based on the potential of the study to meet training planners' needs, there are areas in TREDS which need to be addressed for future development and validation of automated training planning tools for simulation-based training.

Recommendations

Academic, industry and government trainers must exploit computer-based planning and evaluation tools to improve the effectiveness and efficiency of simulation-based training. In this realm, this study has started the process and tested a means for measuring technology's impact on the user. Findings of the present study may not be representative of other groups consisting of different populations since the military population has unique objectives in conducting simulation-based training. The study could yield more significant results in a different environment.

In essence, the effects of technology are being measured using a human-centered approach, versus the usual manner of focusing on the machine. Schneiderman (1992) challenges that the term 'user-friendliness' should be replaced by measurable human-factors quality criteria such as:

1. time to learn,
2. speed of performance,
3. rate of errors by users,

4. retention over time, and

5. subjective satisfaction. (p. 82)

This study has applied only two of the above-mentioned variables—speed of training plan development and subjective user satisfaction. In order to substantiate that the study's hypothesis can be proven, further research should test computer-based planning tools applying the three remaining criteria— (1), (3) and (4). "Time to learn" and "retention over time" could be measured using a extended study testing period. With a similar experimental design set up to measure these criteria, the computer-based planning tool could show significant increases in effectiveness and efficiency.

This study examined the capability of a computer-based planning tool to assist users in building a mental model of the training planning system. According to Eberts (1994) additional feedback capabilities for a final design of a system should follow these guidelines:

1. users need feedback to develop accurate mental models,

2. the system should provide feedback which corresponds to goals and plans of the user, and

3. the system should assess the goals and plans while providing feedback on assessment (p. 525).

Once the TREDS planning tool is completed and tested in its initial domain, these points should be incorporated.

Other areas of simulation-based training should be considered for implementation of a computer-based planning tool. Following a proof-of-principle demonstration in August 1995 with Orange County, Florida, the Plowshares program will continue to "apply military constructive simulation technology to training and analysis for emergency management" (Petty & West, 1995). Included with the Plowshares program is a derivative of TREDS which is the System for Training Emergency Personnel (STEP) (McGinnis, 1994). STEP is a computer-based planning tool which will assist in the overall planning and assessment of the Plowshares simulation-based emergency team training exercises (McGinnis, 1994).

Other application areas for automated planning in simulation-based team training include the nuclear power plant industry, aviation simulator programs, space exploration, sports and business strategic executive simulations. Sports training could also apply a computer-based training planning tool to assist in the analysis of team or collective tasks. A team has a mission that it often simulates during practice on how to score points in a football game or goals in a soccer match. These sports already conduct simulated scouting exercises each week when they try to guess how their opponent will play in the next game. A computer-based system would serve to save time and efforts for future replays against similar teams annually, while tracking the progress of the team to perform its assigned tasks.

One benefit of having the computer-based training planning tool replicate expert models of the training planning process is suggested by Totterdell, Norman, and Browne,

(1987) in that the best technology may be the kind which adjusts to the operator instead of compelling users to tailor to the technology. As engineers and computer programmers create new systems, they should follow the user design guidance offered in the human-computer interaction literature. Validating this point, Helander (1988) asserts that the cognitive psychologists must develop guidelines for the designers of computer systems in order to match human capabilities with complex system requirements.

The future direction in computer-based technological implementations is continuously exploited in our daily lives. The scientific application of knowledge-based systems to help users navigate through software may be a starting point for bridging the gap between system designers (represented by computer programmers and engineers) and users (represented by the psychologists). As computer-based planning tools surface, the same theories for mental model replication and evaluation used in this study should be applied. Understanding the cognitive mental models of the users must still be considered before this technology evolves further.

Once a user becomes very familiar with the planning process, their mental model is mature, dispensing the need for an elaborate planning tool. According to Eliot (1994) intelligent agents are "software that acts on the behalf of a human master to achieve a desired goal" (p. 9). At the point of complete familiarity with a process, the computer-based planning tool could be transformed into an intelligent agent which could replicate the user's mental model. The intelligent agent would perform training planning development as the user and eventually the agent could become a super-agent by

collating and synthesizing all of the training planning experts into an super expert training planner agent. Rouse and Howard (1993) support this conclusion by predicting that:

> Trends in computer and communications technologies promise to make these types of support system increasingly powerful and widely available. It is easy to envision integrated planning systems, utilizing multiple, enterprise-tailored advisors. In addition, multimedia, simulation, and groupware technologies can enable highly interactive, distributed planning (p. 53).

Summary

As Brynjolfsson (1993) aptly points out, the role of information technology's (IT) contribution to productivity has yet to be determined due to inadequate consensus and proof of reliable IT measurements. Brynjolfsson (1993) states that the main issue is not how fast or how much more we will be able to do with technology, but that IT will enable us "to do entirely new things in new ways" (p. 76). By choosing the appropriate measuring tool for unconventional methods, leaders and managers will be able to define the benefits of the technology.

Today, there are many statements regarding the production enhancements effected by automation. However, the data to support such claims are often unfounded. Through the use and testing of a computer-based planning tool, the results reported in this paper serve to strengthen the premise that automation does enhance productivity.

The purpose of this paper was to utilize behavioral theory to support the rationale for the use of computer-based planning tools for simulation-based training. Data

collection which applied the computer-based planning tool in an experimental setting produced results to show that this new tool produces better results, both in effectiveness and efficiency. These findings are important in that they point to ways to show technology's impact in a quantitative manner for cognitive tasks. The automation offered by technology can save people time and effort.

While mankind proliferates automation applications from the workplace to the home, many people seem to spend more time in front of a computer screen than enjoying life. The novelist Dean Koontz (1994) implies that the effects of automation is not always a positive consequence:

> New technology—like the computer—freed men and women from all kinds of drudgery, saved them vast amounts of time. And yet ... and yet the time saved did not seem to mean additional leisure or greater opportunities for meditation and reflection. Instead, with each new wave of technology, the pace of life increased; there was more to do, more choices to make, more things to experience, and people eagerly seized upon those experiences and filled the hours that had only moments ago become empty (p. 273).

With the extra time and less effort afforded by computer-based planning tools, the intent is not to do more, but to fill the time and add to life the little things that subtly demand attention and often provide great reward. It is with this hope and purpose that the reader finds utility in applying automation to enhance the effectiveness and efficiency of processes such as planning.

APPENDICES

Appendix A

List of Abbreviations and Acronyms

ADD: Automated exercise Distribution and Display

APEP: Automated exercise Preparation, Evaluation and Preview

ARC: Adjusted Ratio of Clustering

ARE: Asymptotic Relative Efficiency

ASG: Automatic Scenario Generator

ATOM: Anti-Air Warfare Teamwork Observation Measure

BOS: Battlefield Operating System

DIS: Distributed Interactive Simulation

GOMS: Goals, Operators, Method, Selection rules

ISD: Instructional Systems Design

IT: Information Technology

METL: Mission Essential Task List

MOE: Measure of Effectiveness

NAWCTSD: Naval Air Warfare Center Training Systems Division

NPP: Nuclear Power Plant

PMOE: Programmatic Measures of Effectiveness

SATS: Standard Army Training System

SME: Subject Matter Expert

TADMUS: Tactical Decision Making Under Stress

TEFL: Training Exercise Force Laydown

TREDS: TRaining Exercise Development System

TVS: Training Value System

Appendix B

Demographics Questionnaire

DEMOGRAPHICS QUESTIONNAIRE

Date: ____________________

All information will be kept in strict confidence. Only aggregate data will be reported. Please provide the following information:

A. General.

1. Name (optional): ________________________ 2. Unit: ____________________

3. Duty Position: ________________ 4. Rank: _____

5. Age: _____ 6. Time in Service: _______

B. Computer-related skills.

1. Rate your experience with personal computers (circle the appropriate response):

1	2	3	4	5	6	7	8	9	10
none			some			average			extensive

2. If you related your experience with personal computers in terms of years, where would you place yourself on the chart below? (circle the appropriate response):

1	2	3	4	5	6	7	8	9	10
none			more than 6 months			over 2 years			over 5 years

3. Approximately how often do you use a personal computer each month? (circle the appropriate response):

1	2	3	4	5	6	7	8	9	10
never			once a week			2-3 times/week			daily

4. Do you own a personal computer? Yes No

5. Have you used Windows before? Yes ☐ No ☐

6. Where do you consider your academic preferences to be? (circle a number the closest to your interests)

1	2	3	4	5
English/ Humanities	Science	Math	Computers	Other

C. Training and Simulation

7. If you related your unit training planning experience in terms of years, where you place yourself on the chart below? (circle the appropriate

1	2	3	4
none	more than 6 months	over 2 years	over 5 years

8. In the last year, how many hours have you spent training in a simulation or device?

1	2	3	4
None	at least 10	at least 25	more than 50

9. Have you used any automated tools in planning for training Yes ☐ No ☐
If yes, which training tools have you used?

10. If applicable, which simulation or simulator devices have you trained

SIMNET ☐ Janus ☐ BBS ☐ Other: ____________

This concludes the Demographic Questionnaire. Thank you for your assistance.

Appendix C

Post-Exercise Questionnaire

POST EXERCISE QUESTIONNAIRE

Team # ______ Date ____________________

Name (optional): ____________________________ Rank ________

All information will be kept in strict confidence. Only aggregate information will be reported.

Please answer the following questions by circling your response:

1. How well did this exercise increase your knowledge of the training process?

1	2	3	4
none	some	average	extensive

2. How similar was this training exercise to your current planning process for unit training?

1	2	3	4
none	somewhat close	similar	very similar

3. How would your peers in other units benefit from such a training system?

1	2	3	4
none	some	average	extensive

4. This planning process for unit training would be good for training the following (mark all of the entries you feel are appropriate):

Individual ○ Crew ○ Platoon ○ Company ○ Battalion Staff

Other: ____________________________

----over----

5. What areas do you consider need improvement in the training planning process?

6. What did you like most about this exercise?

7. What would you change to make this a better exercise?

8. Any other comments you have to contribute would be greatly appreciated.

Thank you for your time and assistance in this exercise.

Appendix D

Practical Exercise for Experiment

SATS-TREDS Janus Practical Exercise

Automated Planning for Simulation-based Training

PMCATT- TREDS-X1 Date: 8 May 95

I. General information:

A. This practical exercises seeks to integrate training needs and objectives with simulation-based training. At home station, leaders evaluate the effectiveness of exercise training plans on the battlefield, in NTC livefire exercises, during SIMNET scenarios, or in Janus combat simulation exercises.

B. Time is always a limited resource for planning training. Building a training exercise plan requires an organized structure of specific aspects in each planning phase. Any comments you have for improving this process will be helpful for future development for all Army training systems.

II. Situation:

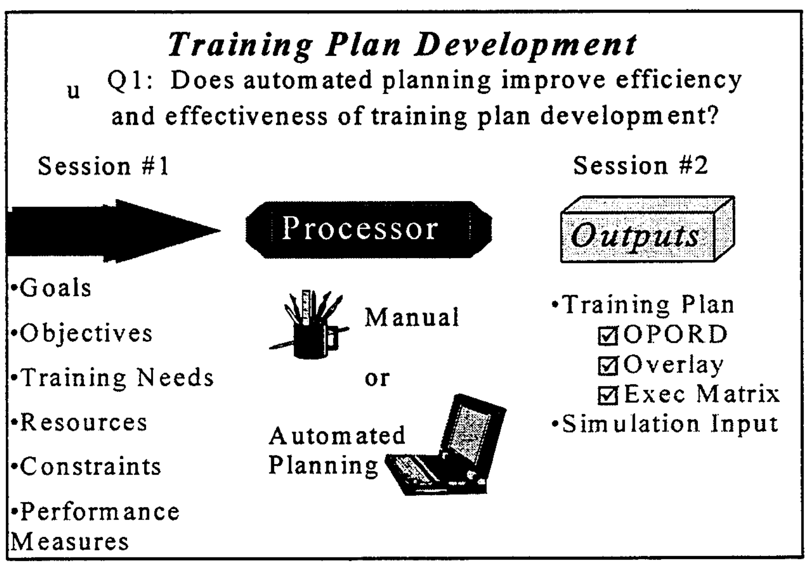
A. Your company, the world-renown *Mike Company* of TF 3-67 AR, is planning training for the fourth quarter of FY 1995, July to September. Key simulation training objectives are outlined in the battalion's quarterly training guidance (see enclosure 1). The Task Force's and company's training highlights are in enclosure 2.

FOR TRAINING PURPOSES ONLY

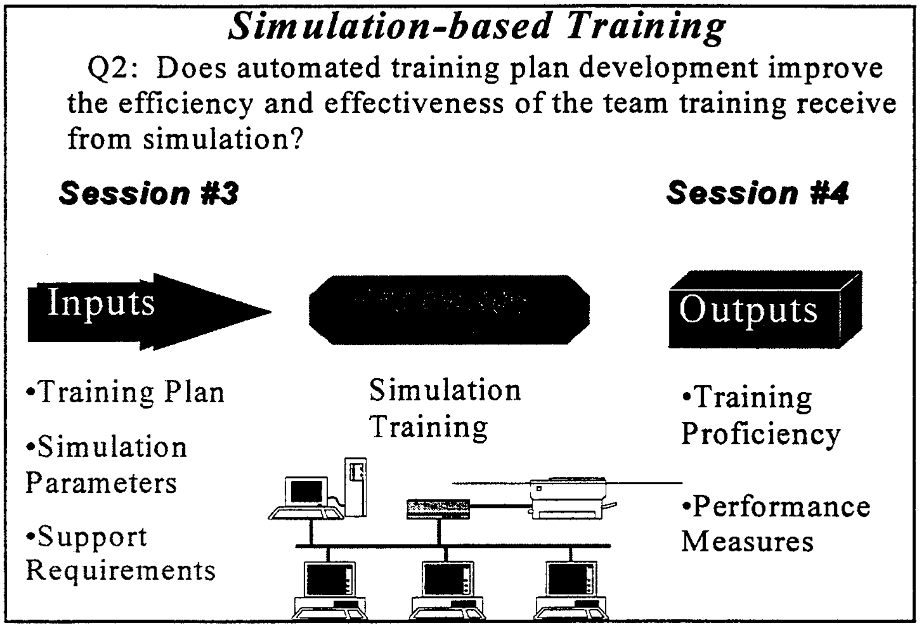
Based on *Mike Company's* November 1994 Co/Tm Level ARTEP results (see encl 4), the BN CDR wants each company to improve proficiency in as many tasks as possible using the cost-effective training offered by the simulation centers.

B. Each company commander should work closely with the S-3 staff on all training planning. The BN CDR has directed the S-3 to assist with all planning. Use the November ARTEP results to orient on specific tasks. For the September NTC rotation, *Mike Company* will be the lead force in the defense missions for the Task Force.

III. Requirements:



Phase I: Training Plan Development



Phase II: Simulation-based Training & Assessment

A. Phase I: The Training Plan Development Phase consists of the following two sessions:

1. Review the training calendar, ARTEP results, current unit METL (encl 3), MTPs, FMs and commander's training guidance to prioritize the tasks for training in a typical Janus scenario (duration of training period not to exceed three hours).

2. Develop paragraphs 2 and 3 of the Operations Order (or the OPORD Matrix), an Operations Overlay, coordinated through an execution/OPORD Matrix for planning a Janus simulation exercise.

FOR TRAINING PURPOSES ONLY

B. Phase II: The Simulation Training Phase consists of two sessions:

1. Establish or review the measures for success on specified standards for the tasks in the scenario you have developed. Observe the simulation and record the values for the selected measures during and/or after the simulation's execution.

2. Using the results of the simulation, assess the new proficiency ratings for only those tasks in the scenario. This will involve rolling up the results of the standards into subtasks, then into tasks ratings.

IV. The Janus Simulation. The Janus combat simulation model will be available for the battalion to train on during selected dates in the fourth quarter. As part of this exercise, there will be an initial Janus "train-up" session for participants to learn Janus fundamentals. Janus lends itself well to conduct staff and leader training. After-action review and "what-if" analyses can also conducted using Janus. Janus simulation output is to be recorded via the Janus post-processing file system.

GEORGE F. STONE III
MAJ, FA

Encls
1: Bn Trng Guidance
2: M Co Trng Highlights
3: M Co METL
4: M Co ARTEP Results
5: MOE for Simulations

FOR TRAINING PURPOSES ONLY

3d Battalion, 67th Armor
2nd Armored Division
Ft. Hood, TX

6 June 1995

Subject: Battalion Training Guidance for 4th Quarter, FY95 (Enclosure 1)

1. *General*: This guidance is for all personnel in 3-67 AR. It will be modified as needed to meet unit training objectives and METL.

2. *Specific*:

a) Units will fully utilize all division simulation assets to prepare for quarterly and annual training exercises. The Janus simulation will be available throughout the quarter for enhancing proficiency on leadership and collective tasks.

b) The Janus simulation tools enable the application of measures of effectiveness to evaluate Go/NoGo standards for MTP standards. These standards have also been assigned Task Performance Support codes for their applicable training capability in Janus. The battalion's goal for increasing the number of Go's on MTP standards through simulation-based training is 25%.

c) Manual and automated planning methods will be essential for bringing training simulation to all soldiers and leaders. All leaders should strive to improve these tools through feedback to the simulation system managers.

d) Leaders should not be stifled by the limitations of simulations. Innovation and initiative should be prevalent in finding ways to maximize simulation utility. To maximize the benefits of training simulations, leaders must become aware of each simulation's capabilities and limitations. Reading simulation reference material and using computer-based training programs will assist greatly.

HOOD
LTC, AR

Enclosure 2: Mike Company's 4th Quarter (FY 95) Training Highlights

July

BN Staff Janus CPX (5-7)

SIMNET Platoon Exercises (12-15)

August

Task Force Leaders Janus CPX (3-5)

Task Force FTX (13-16)

September

NTC Rotation (2-29)

Enclosure 3: Unit METL

Mike Company, 3-67 AR Mission Essential Tasks List

References. ARTEP 71-1-MTP, 3-67 AR Battalion METL, BN Training Guidance, Mike Company Training Guidance.

General. The following tasks will be those mission essential tasks that Mike Company has to perform in order to fulfill its wartime preparation requirements. All other specified and implied tasks will be added as appropriate.

BOS: Maneuver

Task Number	Task	Proficiency
17-2-0323	Withdraw under enemy pressure	Partially trained (P)
17-2-0322	Withdraw not under enemy pressure	Trained (T)
17-2-1021	Defend	Partially trained (P)
17-2-0306	Support by Fire	Untrained (U)
17-2-0202	Perform Reconnaissance	Untrained (U)
17-2-0302	Perform Tactical Road March	Untrained (U)

BOS: Mobility and Survivability

Task Number	Task	Proficiency
17-2-0502	Emplace an Obstacle	Untrained (U)

BOS: Intelligence

Task Number	Task	Proficiency
17-2-0201	Maintain Operation Security	Partially trained (P)

Enclosure 4: Mike Company's November ARTEP Results with Task Performance Support codes for the Janus combat simulation.

(Document is not enclosed due to its length).

Disclaimer: The enclosed ARTEP results are fictitious and do not represent any unit.

Appendix E

Cognitive Analysis Tool Program Rules

```
MAINGOAL "Training Exercise Development OLEsystem";

RULE "Training Exercise Development OLEsystem" "This model portrays the
current conceptual layout of TREDS, vs. 1.0, dated January 1995.";

  METHOD INCOMPLETE "Training Exercise Development";

        STEP "Events",

        STEP "Tasks",

        STEP "Scenarios";

    END;

  END;

RULE "Events";

METHOD INCOMPLETE "The Events are Scheduled Occurrences on the Unit's
Training Calendar";

        STEP GROUP "Record METL",

        STEP "Build Calendars & Schedules";

    END;

  END;

RULE "Tasks";

  METHOD INCOMPLETE "Tasks";

        STEP "Assess Training Proficiency",

        STEP "Prioritize Tasks",

        STEP "Allocate Tasks to Events";
```

```
    END;
  END;
RULE "Scenarios";
  METHOD INCOMPLETE "Scenarios";
        STEP "Select Training Conditions",
        STEP "Select Scenarios",
        STEP "Edit Scenarios",
        STEP "Check TADSS Constraints",
        STEP "Build Input Files & Exercise Products",
        STEP "Capture Assessments";
    END;
  END;
RULE "Record METL";
  METHOD INCOMPLETE "Record METL";
        STEP "Review Current METL",
        STEP "Update METL";
    END;
  END;
RULE "Build Calendars & Schedules";
  METHOD INCOMPLETE "Build Calendars & Schedules";
        STEP "Import Calendar from higher Hqs",
```

```
        STEP "Review Training Guidance",
        STEP "Link training activities with guidance",
        STEP "Review final training schedule";
    END;
  END;
RULE "Assess Training Proficiency";
  METHOD INCOMPLETE "Assess Training Proficiency";
        STEP "Review current proficiency ratings",
        STEP "Review previous training evaluations",
        STEP "Update training proficiency status";
    END;
  END;
RULE "Prioritize Tasks";
  METHOD INCOMPLETE "Prioritize Tasks";
        STEP "Assign commander's guidance to tasks",
        STEP "Rank tasks by weights";
    END;
  END;
RULE "Allocate Tasks to Events";
  METHOD INCOMPLETE "Allocate Tasks to Events";
        STEP "Select the Training Event",
```

```
            STEP "Confirm/revise Current Event Schedule",
            STEP "Notify Personnel of Schedule",
            STEP "Identify Tasks that event can train",
            STEP "Select Tasks to be trained in event";
        END;
    END;
RULE "Select Training Conditions";
    METHOD "Low Level Difficulty";
            STEP "Review METT-T Parameters",
            STEP "Specify Low Level Parameters";
        IF "Lack of Familiarity with Training Device"
            TRY METHOD "Low Level Difficulty";
        IF "Low Training Proficiency on Device"
            TRY METHOD "Low Level Difficulty";
        END;
    METHOD "Medium Level Difficulty";
            STEP "Review METT-T Parameters",
            STEP "Specify Medium Level Parameter Values";
        IF "At least 25% Improvement on Low Level Difficulty Exercises"
            TRY METHOD "Medium Level Difficulty";
        END;
```

```
  METHOD "High Level Difficulty";
      STEP "Review METT-T Parameters",
      STEP "Specify High Level Parameters";
   IF "At least 20% Improvement on Medium Level Difficulty Exercises"
    TRY METHOD "High Level Difficulty";
   IF "At Least 50% Improvement over Low Level Difficulty"
    AND "Initial Lack of Familiarity with Training Device"
    TRY METHOD "High Level Difficulty";
   END;
  END;
 RULE "Select Scenarios";
  METHOD "By Weight Method";
      STEP "Examine Current Rankings",
      STEP "Choose Tasks to Train",
      STEP "Match Selected Tasks against Library Scenarios";
   IF "Improve Current Training Deficiencies"
    TRY METHOD "By Weight Method";
   END;
  METHOD "Group by Tactical Category";
      STEP "Determine Training Event Objectives",
      STEP "Match Objectives with Tactical Category",
```

```
        STEP "Link Tactical Category Tasks to Library Scenario";
    IF "Preparation for a Specific Mission is Essential"
      TRY METHOD "Group by Tactical Category";
    IF "Tasks Logically Grouped into Specific Categories"
      TRY METHOD "Group by Tactical Category";
    END;
  END;
RULE "Edit Scenarios";
  METHOD INCOMPLETE "Edit Scenarios";
        STEP GROUP "Review/edit Execution Matrix",
        STEP GROUP "Review/edit Operations Overlay",
        STEP "Review/edit Operations Order";
    END;
  END;
RULE "Check TADSS Constraints";
  METHOD INCOMPLETE "Check TADSS Constraints";
        STEP "Identify Specific TADSS",
        STEP "Conduct Constraint-based Allocation of Resources",
        STEP "Incorporate Trainability Factors";
    END;
  END;
```

```
RULE "Build Input Files & Exercise Products";
  METHOD INCOMPLETE "Build Exercise Products";
        STEP "Review Input Files",
        STEP "Generate Exercise Output Products";
    END;
  END;
RULE "Capture Assessments";
  METHOD "Exercise Playback";
        STEP "Replay exercise",
        STEP "Assess and Explain Areas of Concern",
        STEP "Catalog/save Replay Files for Future AARs";
    IF "Time Available for AAR is > 2 hrs"
      TRY METHOD "Exercise Playback";
    END;
  METHOD "Review Performance Measures";
        STEP "Evaluate Measures of Effectiveness",
        STEP "Summarize MOE for Follow-up Training",
        STEP "Record/print Measures and Summary";
    IF "Unit Commander Desires Analytical Feedback"
      TRY METHOD "Review Performance Measures";
    END;
```

```
METHOD "Observer-controller";
   STEP "Tracks the scenario's Main Events",
   STEP "Records Observations by BOS Areas",
   STEP "Presents Recommendations for Improvement",
   STEP "Prepares Written Report";
 IF "An OC was on-site at Simulation"
  TRY METHOD "Observer-controller";
 END;
END;
EXCEPTION;
END;
```

Appendix F

The Training Value System

The modified TVS model proposed by Fitz-enz (1994) consists of the following actions:

a. Pre-training status of a team is examined by:

   (1) identifying command training objectives and criterion for success;

   (2) selecting a target training audience and level;

   (3) choosing tasks which are essential for mission success;

   (4) prioritizing tasks based on training proficiency and performance; and

   (5) establishing the need for a gain in performance by the assessment of the team's current training proficiency through a pre-test.

b. Training analysis is a two-step process involving:

   (1) problem diagnosis; and

   (2) training description of:

      a) the need for training on a set of tasks;

      b) doctrinally-correct tactical scenarios;

      c) the applicable training devices and/or simulations; and

      d) available training resources.

c. Training event selection and assessment consists of:

   (1) choosing a live field training event, constructive simulation-driven exercise or virtual battlefield exercise;

   (2) identifying the variables which effected performance; and

   (3) determining how training changed performance.

d. Final training effectiveness is assessed by:

   (1) measuring the new training proficiency level and then calculating the effectiveness of training due to differences in quality, productivity and capability to execute missions between the pre-test and the final test;

   (2) deciding if additional training will be required; and

(3) comparing against similar simulation-based training exercises (if no pre-test was conducted).

Appendix G

Free Recall and Position Memory Forms

Free Recall Memory Form

Subjects drew or outlined their conceptual understanding of the training planning process. This information served to demonstrate whether subjects were able to increase their understanding of the training planning development process. The diagrams are pictorially represented and kept in the author's experimental data collection.

Build a Diagram, Picture, or Flow Chart to Show the Components of a Training Planning Model for Simulation-based Training

Training Planning for Simulations-- Position Memory Testing

(Solution Sheet to determine ARC values)

Events: When to Train	*Tasks: What to Train*	*Scenarios: How to Train*
9	2	11
3	8	10
	1	7
		4
		5
		6

In a Logical Order, fill in the above categories with the components of a training planning model

Use the number to indicate position on the chart above:

1. Allocate Tasks to Events
2. Assess Training Proficiency
3. Build Calendars & Schedules
4. Build Input Files & Exercise Products
5. Capture Assessments
6. Check TADSS Constraints
7. Edit Scenarios
8. Prioritize Tasks
9. Record METL
10. Select Scenarios
11. Select Training Conditions

Appendix H

Free Recall Adjusted Ratio of Clustering Data

ARC Value Results (from Free Recall Testing)

Automated Teams			***Manual Teams***		
ID#	***Pretest***	***Posttest***	***ID#***	***Pretest***	***Posttest***
A011	-0.10	-0.10	B021	0.12	-0.32
A041	-0.32	0.56	B031	0.12	-0.10
A042	0.34	0.12	B061	-0.10	0.12
A051	-0.76	-0.10	B062	-0.32	-0.54
A121	-0.76	-0.10	B111	0.34	1.00
A122	-0.10	0.56	B131	0.12	-0.10
A161	-0.32	-0.10	B132	-0.10	-0.32
A171	-0.10	0.12	B152	-0.32	-0.32
A201	-0.32	0.34	B181	0.12	-0.32
A221	-0.10	0.34	B182	-0.32	-0.32
A241	-0.32	-0.10	B211	-0.32	-0.76
A311	0.12	0.34	B212	0.12	0.12
A312	-0.10	0.12	B231	-0.10	0.56
A351	0.34	0.78	B251	-0.10	-0.32
A361	-0.76	-0.76	B301	0.12	0.12
A362	-0.76	-0.32	B302	-0.10	-0.10
A401	-0.32	-0.10	B331	-0.32	0.56
A421	-0.10	0.34	B332	0.34	0.12

Automated	Pretest	Posttest	Manual	Pretest	Posttest
A431	-0.54	-0.32	B341	-0.54	-0.10
A432	0.34	0.12	B411	0.12	-0.32
A451	0.12	0.56	B441	-0.32	-0.10
A511	-0.32	-0.10	B551	0.12	0.12
A512	-0.10	-0.32	B552	-0.54	0.78
A521	-0.10	0.78	B561	0.12	0.12
A522	0.34	0.12	B562	-0.32	0.12
A531	0.12	0.12	B571	-0.10	0.78
A532	0.12	0.56	B572	-0.10	0.56
A541	-0.32	-0.32	B581	-0.10	-0.10
A542	0.34	0.12	B582	0.56	0.34
A611	0.12	-0.10	B651	-0.32	0.12
A621	-0.54	-0.10	B652	-0.54	-0.10
A622	-0.10	0.34	B661	-0.10	-0.76
A631	-0.54	-0.32	B671	0.12	0.12
A711	-0.10	0.12	B672	-0.32	0.12
A712	0.12	0.12	B751	-0.10	-0.32
A721	-0.76	0.12	B752	-0.76	-0.54
A731	-0.10	0.12	B761	-0.10	-0.10
A732	-0.32	0.12	B762	-0.10	-0.32
A741	0.56	0.12	B771	-0.76	-0.32

Appendix I

Position Memory ARC Data

ARC Value Results (from Position Memory Testing)

Automated Teams			*Manual Teams*		
ID #	***Pretest***	***Posttest***	***ID #***	***Pretest***	***Posttest***
A011	0.12	0.34	B021	0.34	-0.76
A012	-0.32	*	B022	-0.54	*
A041	-0.10	0.12	B031	-0.10	-0.10
A042	-0.54	0.56	B032	0.12	*
A051	-0.10	0.34	B061	-0.76	-0.54
A052	-0.76	*	B062	-0.76	0.34
A121	-0.10	0.12	B111	0.34	-0.10
A122	-0.32	-0.32	B131	-0.10	0.34
A161	0.12	0.12	B132	0.12	-0.54
A162	0.56	0.56	B152	-0.10	0.12
A171	0.34	*	B181	0.12	0.34
A172	-0.76	*	B182	-0.32	0.34
A201	0.34	-0.10	B211	-0.32	-0.32
A202	0.12	-0.32	B212	0.34	0.12
A221	0.12	*	B231	-0.10	0.56
A222	0.56	0.34	B251	0.78	0.56
A241	-0.76	-0.10	B252	0.56	0.34
A242	0.12	0.78	B301	-0.32	*
A311	0.34	0.34	B302	0.78	0.34

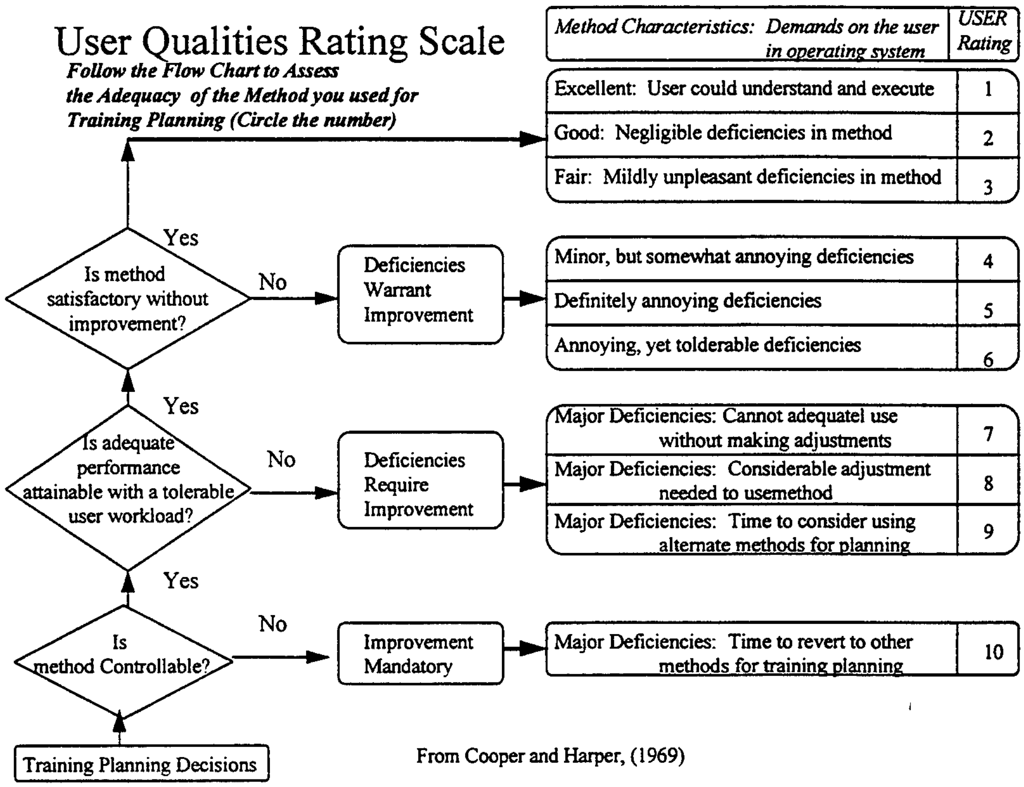
A312	0.12	0.12	B331	0.56	0.56
A351	*	1.00	B332	0.34	0.34
A352	*	0.12	B341	0.12	0.12
A361	0.56	0.78	B342	0.78	0.12
A362	*	*	B411	0.12	-0.10
A401	0.34	0.34	B412	0.34	0.34
A402	0.34	0.56	B441	0.12	-0.10
A421	-0.10	0.34	B442	*	0.34
A422	-0.10	0.78	B551	-0.10	-0.32
A431	-0.10	-0.32	B552	-0.10	-0.32
A432	*	*	B561	0.56	-0.32
A451	-0.32	-0.10	B562	0.12	0.34
A452	-0.10	0.78	B571	0.56	0.56
A511	0.78	0.78	B572	0.34	0.56
A512	0.34	1.00	B581	-0.54	0.56
A521	0.12	0.56	B582	-0.54	0.12
A522	0.34	0.78	B651	-0.10	-0.54
A531	0.12	0.78	B652	0.56	0.34
A532	0.56	0.34	B661	-0.10	0.78
A541	-0.32	-0.10	B662	0.12	-0.10
A542	0.34	0.12	B671	0.56	*
A611	0.34	-0.32	B672	0.12	-0.32

A612	-0.10	0.12	B751	-0.10	0.34
A621	0.78	0.56	B752	0.34	0.56
A622	-0.54	-0.32	B761	-0.76	-0.76
A631	-0.10	-0.76	B762	0.34	0.34
A632	0.78	-0.10	B771	0.34	0.34
A711	0.34	0.34	B772	0.12	-0.10
A712	0.12	0.12			
A721	0.12	-0.32			
A722	0.12	0.56			
A731	*	-0.10			
A732	0.12	0.56			
A741	0.34	0.34			
A742	-0.10	-0.10			

*Indicates that the form was either not filled out or incorrectly completed. The data were unusable in these cases.

Appendix J

Quality Rating Form



From Cooper and Harper, (1969)

Appendix K

Quality Rating Data

Quality Ratings by Teams

Automated Teams	Score	Manual Teams	Score
A1	3	B2	3.5
A4	2.33	B3	5.5
A5	2	B6	6
A12	2	B11	6
A14	1	B13	5
A16	4	B15	1.5
A17	2.5	B18	5.5
A20	1	B21	3.5
A22	3.5	B23	5
A24	4	B25	4
A31	1.5	B30	5.5
A36	4.5	B33	6
A40	1	B34	4.5
A42	2	B41	2.5
A43	3	B44	5
A45	2	B55	6
A51	3	B56	4
A52	3	B57	3.5
A53	2.5	B58	3
A54	2.5	B65	3.5

Automated Teams	Score	Manual Teams	Score
A61	1.5	B66	2
A62	2	B67	2
A63	4.5	B75	3.5
A71	4	B76	2.5
A72	2.5	B77	[illegible]
A73	4		
A74	2.5		
Avg:	**2.64**		**4.12**

Appendix L

Simulation MOE Definition and Form

Measures of Effectiveness:

MOE #1: *Number of Tanks (M1s) which survived:* ____

MOE #2: *Number of Mechanized Infantry vehicles (M2s) which survived:* ____

MOE #3: *Number of Enemy ground forces killed:* _____

Record of Tasks trained in Janus: (Use for Sessions #1 & #4)

Proficiency of Training (this data were collected, but not used in the analysis for the hypothesis or study conclusions)

Task #	Training Task	Initial	Final

Appendix M

Simulation MOE Data

Results of Janus Simulation Iterations by Teams*

#M1s Survived	#M1s Survived	#M2s Survived	#M2s Survived	#Enemy Killed	#Enemy Killed
Manual	Auto	Manual	Auto	Manual	Auto
8	7	2	4	47	52
8	8	0	0	44	52
4	8	0	0	52	47
5	5	1	0	27	53
8	9	1	2	45	28
6	4	1	0	38	52
9	7	1	1	42	42
6	3	1	0	41	47
7	7	0	0	43	47
8	7	2	0	46	45

*This is one part of the study where the data were not collected well due to users not following directions to ensure that all forms were filled out completely. In some cases, the simulation exercise was closed out too soon to enable collection of this data.

Appendix N

Task Load Index Scores Form

TASK LOAD INDEX RATING SHEET

Team # ______ Session # ____ Date __________________

All responses will be kept in strict confidence. Only aggregate information will be reported. Please answer the following questions by placing a check in the appropriate interval.

1. ***Mental Demand***: How much thinking, deciding, searching, remembering or looking was required in the previous session?

Low High

2. ***Physical Demand***: How much physical activity was required?

Low High

3. ***Temporal Demand***: How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

Low High

4. ***Performance***: How successful do you think you were in accomplishing the goals of the session set by the experimenter?

Good Poor

5. ***Effort***: How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low High

6. ***Frustration***: How discouraged, irritated, stressed and annoyed versus secure, gratified, content and relaxed did you feel during the session?

Low High

Adapted from Hart and Staveland (1988)

Appendix O

Task Load Index Scores Data

Manual Team Task Load Index Scores by Factor (with weighting)

TM #	Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustration	SUM
B2	43.00	4.83	54.00	44.00	49.50	19.67	215.00
B3	56.58	8.33	38.50	12.75	52.50	39.58	208.25
B6	47.50	1.67	31.00	32.67	34.00	49.58	196.42
B11	60.00	2.08	99.75	35.50	43.75	17.00	258.08
B13	58.33	0.00	21.33	33.25	79.17	10.17	202.25
B15	70.83	0.00	21.67	36.00	21.67	11.33	161.50
B18	81.75	0.00	30.00	36.67	47.00	19.75	215.17
B21	35.42	0.00	12.00	12.67	39.00	27.42	126.50
B23	56.00	0.00	18.00	13.00	35.83	4.83	127.67
B25	60.67	0.00	26.50	44.00	34.00	10.67	175.83
B30	79.33	4.17	48.50	21.50	45.83	29.33	228.67
B33	47.25	1.08	22.67	32.67	26.75	49.33	179.75
B34	57.75	1.50	10.67	22.67	78.00	16.50	187.08
B41	42.00	2.83	32.08	39.67	51.75	0.00	168.33
B44	42.50	0.00	14.17	73.33	41.50	46.00	217.50
B55	67.17	0.00	22.50	23.83	42.83	49.17	205.50
B56	90.50	2.33	35.00	19.00	58.58	16.83	222.25
B57	25.50	1.17	8.92	21.67	23.33	5.25	85.83
B58	72.67	1.08	54.67	22.00	54.50	21.00	225.92

TM #	Mental Demand	Physical Demand	Temporal Demand	Perform ance	Effort	Frustration	SUM
B65	58.17	0.00	30.42	35.17	32.00	11.67	167.42
B66	60.00	6.33	23.25	16.75	36.00	22.83	165.17
B67	50.67	3.00	23.67	23.50	44.67	14.00	159.50
B75	43.00	0.00	5.83	16.67	60.00	18.67	144.17
B76	87.50	7.00	35.00	27.00	55.00	0.00	211.50
B77	30.50	0.00	34.67	5.14	19.49	43.46	133.26

Automated Team Task Load Index Scores by Factor (with weighting)

TM #	Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustration	SUM
A1	84.17	0.00	27.00	34.50	28.67	27.67	202.00
A4	32.00	0.00	40.83	55.00	46.50	16.00	190.33
A5	43.00	11.83	23.33	47.33	71.67	0.00	197.17
A12	35.58	1.92	11.33	26.25	23.00	12.75	110.83
A14	41.00	0.00	46.67	17.00	23.00	24.50	152.17
A16	75.00	0.00	54.67	45.50	12.33	24.00	211.50
A17	44.58	4.42	28.00	21.50	57.33	64.50	220.33
A20	54.00	0.00	14.50	20.00	44.33	29.50	162.33
A22	47.83	2.08	28.33	43.33	39.00	6.08	166.67
A24	48.00	0.00	14.00	18.00	95.00	69.33	244.33
A31	52.50	5.33	31.50	40.67	27.92	4.42	162.33
A36	45.00	1.67	37.00	49.33	21.00	36.67	190.67
A40	76.67	3.33	30.50	41.50	33.00	0.00	185.00
A42	32.00	0.00	23.50	23.00	61.67	8.83	149.00
A43	34.67	2.17	9.50	30.83	17.00	12.00	106.17
A45	37.33	0.00	58.33	27.00	10.67	13.33	146.67
A51	44.00	0.00	21.50	42.67	21.00	8.50	137.67
A52	57.75	0.00	22.92	16.33	32.50	27.00	156.50
A53	48.00	0.00	25.42	46.50	44.67	12.33	176.92

A54	24.58	0.00	31.33	9.92	21.25	20.42	107.50
A61	23.17	0.00	11.00	6.67	15.50	12.00	68.33
A62	51.17	0.00	30.50	30.17	27.17	8.00	147.00
A63	57.08	4.25	47.58	35.83	39.08	14.33	198.17
A71	48.00	2.25	44.33	34.33	54.50	44.92	228.33
A72	42.42	0.00	30.25	18.50	25.50	22.00	138.67
A73	39.58	2.17	22.50	41.50	35.17	27.67	168.58
A74	54.33	3.75	17.50	34.75	54.92	4.17	169.42

Appendix P

Performance Times Form

Training Planning Practical Exercise Assignment & Time Sheet

- *Team Assignment: You are the team leader for Team #* _________

- Please take a few minutes to ensure your team understands the instructions for the Practical Exercise. Brief your group leader (MAJ Stone or Dr. Crissey) at the end of each session to ensure you have met the session requirements, in order to proceed to the next phase of the exercise.

Results will be aggregated to determine total and average times by group.

Please ensure you be as accurate as possible in recording your times. Once you have completed a Session, take a break and then return to begin the next session.

#	Session	Start Time	End Time	Total Minutes
1	Analyzing and Prioritizing Tasks	____:____	____:____	______
2	Building Training Simulation Scenario	____:____	____:____	______
3	Preparing & Running the Simulation	____:____	____:____	______
4	Assessing Proficiency from the Simulation Exercise	____:____	____:____	______

Appendix Q

Performance Times Data

Manual Team Times by Session

TM#	T1_M	T2_M	T3_M	T4_M	T_TOT M
B2	30	80	60	30	200
B3	30	90	70	35	225
B6	30	100	60	30	220
B11	30	80	120	20	250
B13	30	45	85	30	190
B15	20	34	105	20	179
B18	45	75	115	14	249
B21	25	35	120	25	205
B23	21	45	115	19	200
B25	25	25	140	15	205
B30	32	61	98	15	206
B33	27	59	160	10	256
B34	30	60	120	55	265
B41	40	56	96	20	212
B44	50	75	70	15	210
B55	72	95	175	30	372
B56	55	90	170	170	485
B57	43	53	225	23	344
B58	51	90	195	30	366

TM#	**T1_M**	**T2_M**	**T3_M**	**T4_M**	**T_TOT M**
B65	70	95	200	30	395
B66	75	90	175	20	360
B67	50	122	122	22	316
B75	53	70	105	22	250
B76	67	85	180	30	362
B77	47	86	105	45	283
Avg:	41.92	71.84	127.44	31	272.2

Automated (TREDS) Team Times by Session

TM#	T1_A	T2_A	T3_A	T4_A	T_TOT A
A1	25	135	60	15	235
A4	28	102	35	32	197
A5	31	120	20	37	208
A12	35	115	50	6	206
A14	35	68	60	13	176
A16	60	44	90	15	209
A17	45	53	60	13	171
A20	18	45	35	30	128
A22	12	110	45	35	202
A24	30	75	90	70	265
A31	20	90	40	15	165
A36	30	120	75	10	235
A40	20	138	100	35	293
A42	16	75	90	18	199
A43	8	76	125	15	224
A45	20	30	200	30	280
A51	12	110	60	15	197
A52	9	130	120	30	289
A53	17	110	188	10	325

TM#	**T1_A**	**T2_A**	**T3_A**	**T4_A**	**T_TOT A**
A54	7	113	192	21	333
A61	11	144	103	25	283
A62	11	116	50	30	207
A63	60	110	40	60	270
A71	45	120	120	45	330
A72	25	125	135	45	330
A73	20	130	118	25	293
A74	18	127	30	25	200
Avg:	24.741	101.148	86.333	26.667	238.889

Appendix R

Demographics Questionnaire Data and Results

Demographics Data for the Manual Teams-- Background Information

Team#	Position	Rank	Age	Time in Service (yrs)	Time in Unit (yrs)
B2	PLT SGT	E7	47	14.00	1.00
B2	PLT LDR	O2	25	3.00	2.50
B3	SEC LDR	E6	31	9.00	2.50
B3	XO	O2	25	2.00	2.00
B6	SPT PL	O2	26	3.00	2.25
B6	MED PS	E7	37	19.00	2.17
B11	ASST S3AIR	O1	23	0.67	0.17
B11	CMPTR OPS	E4	27	4.00	0.50
B13	CO CDR	O3	31	9.00	0.42
B13	TNG NCO	E6	31	15.00	3.00
B15	PLT LDR	O1	33	6.00	0.17
B15	OPS NCO	E6	30	11.00	3.00
B18	TM CHIEF	E6	38	9.00	2.00
B18	PLT SGT	E7	33	13.58	0.06
B21	XO	O2	26	4.00	1.17
B21	MG	E6	32	10.00	0.50
B23	PLT LDR	O1	23	2.00	1.50
B23	PLT SGT	E7	37	18.00	3.00

B25	XO	O2	26	4.00	0.04
B25	1ST SGT	E8	42	22.00	0.75
B30	PLT LDR	O1	23	1.00	0.42
B30	PLT SGT	E7	37	15.00	1.50
B33	BICC	O1	25	2.00	0.83
B33	INTEL SPEC	E4	31	8.50	1.00
B34	PLT LDR	O1	26	5.00	0.42
B34	TNG NCO	E5	24	4.50	0.02
B41	PLT LDR	O2	30	8.00	2.00
B41	PLT SGT	E7	39	18.00	3.00
B44	XO	O2	25	3.00	2.00
B44	PLT LDR	O1	25	2.00	1.50

Team#	Position	Rank	Age	Time in Service (yrs)	Time in Unit (yrs)
B55	CO FSO	O1	24	0.67	1.50
B55	PLT SGT	E5	29	9.00	2.00
B56	PLT LDR	O1	22	1.00	0.33
B56	PLT SGT	E7	32	12.00	3.00
B57	XO	O2	24	2.00	0.67
B57	PLT SGT	E7	29	11.80	0.50
B58	BN S2	O3	29	5.75	1.00
B58	PLT LDR	O2	25	6.00	1.42
B65	XO	O2	25	3.50	0.33
B65	PLT LDR	CDT	22	0.00	0.04
B66	PLT LDR	O2	26	3.00	1.17
B66	TANK CDR	E6	37	19.00	3.00
B67	PLT LDR	O1	22	1.00	0.50
B67	PLT SGT	E6	40	15.00	2.00
B75	PLT LDR	O1	26	3.00	0.08
B75	PLT SGT	E6	32	13.00	1.50
B76	GUNNER	E5	30	12.00	3.50
B76	TANK CDR	E6	35	15.00	0.25

B77	TANK CDR	E6	29	11.00	0.08
B77	GUNNER	E5	23	3.50	3.25

Demographics Data for the Automated Teams-- Background Information

Team#	Position	Rank	Age	Time in Service (yrs)	Time in Unit (yrs)
A1	MED PL	O2	25	2.00	2.00
A1	SEC LDR	E6	32	12.00	0.02
A4	CO CDR	O3	29	7.00	0.92
A4	MORT PL	O2	24	4.00	1.50
A4	PLT SGT	E7	31	11.00	1.00
A5	SQD LDR	E5	30	7.00	0.33
A5	TNG NCO	E5	29	9.00	0.42
A12	S3 AIR	O3	30	9.00	0.33
A12	TNG CLERK	E4	24	3.00	1.00
A14	PLT SGT	E6	29	11.00	1.00
A14	NBC NCO	E5	27	4.50	0.42
A16	TANK CDR	E6	33	12.00	0.08
A16	PLANS OFF	O2	27	3.00	0.50
A17	SCOUT PL	O1	23	1.00	0.33
A17	HQ TANK	E7	43	19.00	0.02
A20	CO CDR	O3	32	6.00	0.33
A20	INTEL	E5	25	8.00	0.50

	NCO				
A22	PLT LDR	O1	33	4.00	1.00
A22	PLT SGT	E7	34	16.00	1.75
A24	PLT LDR	O1	30	5.00	0.58
A24	PLT SGT	E7	34	15.00	2.00
A31	TANK CDR	E6	32	12.00	2.00
A31	CO CDR	O3	29	7.00	0.25
A36	PLT LDR	O1	24	1.00	0.42
A36	PLT SGT	E6	30	15.00	1.00
A40	CO CDR	O3	36	12.00	0.50
A40	TANK CDR	E6	27	8.00	0.42
A42	PLT LDR	O2	24	2.00	0.33
A42	PLT SGT	E7	32	15.00	1.50
A43	TRNG OFF	O3	27	6.00	2.00
A43	BMO	O2	25	3.00	2.00
A45	S3	O4	37	12.00	0.50
A45	TANK CDR	E6	32	11.00	0.67

Team#	Position	Rank	Age	Time in Service (yrs)	Time in Unit (yrs)
A51	CO CDR	O3	31	6.50	1.17
A51	PLT SGT	E6	35	16.00	4.00
A52	PLT LDR	O1	28	9.00	0.33
A52	PLT LDR	O2	25	2.00	0.50
A53	PLT LDR	O1	22	1.00	0.33
A53	PLT LDR	O1	23	1.00	0.67
A54	PLT LDR	O1	22	1.00	0.50
A54	TANK CDR	E5	30	7.00	2.00
A61	S3 SGM	E9	42	22.00	1.00
A61	1ST SGT	E8	40	19.00	3.50
A62	CO CDR	O3	28	5.00	0.25
A62	PLT LDR	CDT	20	0.00	0.04
A63	GUNNER	E5	23	5.00	0.50
A63	CO FSO	O2	23	2.00	0.33
A71	TANK CDR	E6	34	10.00	1.50
A71	PLT LDR	CDT	21	0.00	0.04
A72	CO FSO	O1	23	1.08	0.25
A72	TANK	E6	31	11.00	3.00

	CDR				
A73	CO CDR	O3	26	5.00	0.08
A73	GUNNER	E5	27	4.50	0.42
A74	BN NBC NCO	E6	30	12.00	3.00

Appendix S

Post-Exercise Questionnaire Data and Feedback

Post-Exercise Questionnaire Statistical Results

Knowledge Increase

Mann-Whitney Test

KI_M (Knowledge Increase_Manual Teams)'

'KI_A (Knowledge Increase_Automated Teams)

KI_M N = 25 Median = 2.5000

KI_A N = 27 Median = 3.0000

Point estimate for ETA1-ETA2 is 0.0000

95.2 Percent C.I. for ETA1-ETA2 is (-0.5000,0.0001)

W = 601.5

Test of ETA1 = ETA2 vs. ETA1 < ETA2 is significant at 0.1339

The test is significant at 0.1254 (adjusted for ties), showings a 87.5% confidence that the automated teams increased their knowledge of the process over the manual teams based on a 4-point Likert scale with 4 being the most extensive increase in Knowledge. These results are not significant at the study's level of 5%.

Open-ended Questions

5. WHAT AREAS DO YOU CONSIDER NEED IMPROVEMENT IN THE TRAINING PLANNING PROCESS?

- Need more experience first.
- The amount of time it takes to ID task and sub-task.
- The system needs to be streamlined somewhat. Recognizing it is brand new to us, it was not as user friendly as it could have been. Direction in each window or window "hints" could greatly help speed us up.
- Due to limitations here at Ft Knox, more time is needed for the running of the scenarios.
- None. It is very thought out, and by the book, excellent program.
- This training is best suited for a level higher than PLT.
- Software needs to be fine tuned.
- Better blocks of instructions.
- Different material and tasks.
- How we train via increased creativity to achieve training standards.
- Longer time to work with OP orders.
- Resource management.

- Area where you could research training.

- Input from unit to be trained.

- Program is very well put together. There are no specific areas that need particular improvements, but I would like more time on the "hands-on" training.

- Too many windows to deal with on programs (i.e., easier if some lists were printed)

- The planning process works very well with TREDS. However, the training process needs to incorporate both simulation and real life training (i.e., an actual OPORD briefed and graded by MTP in conjunction with the simulations). Simulations are not a stand-alone item.

- Increased interaction with supporting/other units and higher HQ on Janus.

- Something to list needed material for training being planned.

- Individual and squad level tasks.

- I felt like we went straight into "run" with this exercise. What happened to crawl and walk?

- Bug in the database system.

- As the "B" team our method is the same method that I have used since 1986. These questions focus on the "A" team and not what I did today.

- The orders need to be broken down and explained, and how they are put together.

- Planning to cover all elements of the task your are training on.

- Better understanding of the training objective/walked into class with no idea what was going to happen.
- The level at which success or failure are met.
- Understanding all the applicable icons that enhance the overall system.
- Time to train.
- More flexibility to be able to drive the process instead of process being dictated to you.
- Just big ironing.
- Having a clear focus of what tasks need training. Be more realistic about what benefits may be derived from Janus.
- A little more user friendly for inexperienced computer operators.
- The current planning process is sometimes tedious.
- More understanding of each individual task.
- Proper standardized assessment.
- Minor software glitches.
- Proper identification of "to be trained tasks".
- Integration of slice elements.
- Reduce repetition of information in oporders.

- Need more time.
- A prior knowledge of the steps involved.
- An honest assessment of where you stand.
- Once training is planned - we need to be able to carry it out rather than canceling it because of unexpected stupid details.
- Time to learn MS Word, MS Power Point. Contrary to popular belief, these programs have not been fielded below BN level.
- Very little improvement needed.
- Is good from tank commander position.
- Easier access to hard copies. Try to put more info on less separate lists and files.
- How the METL is linked up to the task.
- Time to conduct realistic training.
- Time.
- I think it would be better if you came up with your plan without the computer, then use the computer to see how effective your plan was. (Not adjust vehicles when on computer)
- The process integration of getting into the program, misinformation, and misunderstanding of reason of purpose.
- Computer skills.

- Shorter training periods.

- Issue operation orders/execution.

- Develop all configurations or train distracters that may occur and try to avoid them. Implement more Top Down oriented training platform.

- Scheduling of training and utilization of resources.

- Possibly additional hands on for computer. As well as, a thorough knowledge of expectations prior to arrival.

- Determining task to be trained on, then prioritizing those tasks.

- The area of planning, preparing and writing an operations order, so that it is simplified for junior leaders.

- Make the computers more rugged.

- Try to bring this to an Army intellect level, i.e., this is presented like the serious, academic design it is, but will need to be understood and used by people with much less academic training and confidence.

- Fewer sub-task listings in the ARTEP. Examples of what qualify T, P, or U.

- As much as the METL should drive training, there are many other missions we must accomplish, maintenance, red cycle, etc., and I did not see a way to plan for that. Additionally, with the constant flux in missions, especially OOW, having an MTP driven training plan can lead an outside observer to believe that there is not training going on. i.e., I-66 goes to Cuba to guard Haitians and does no METL training for 3 months because riot suppression is not in the MTP.

- Obtaining time and training resources. Assessing unit proficiency and retraining.

- The graphics (overlay) process is difficult to use. It is difficult to use a map on a screen. It is much easier to draw the graphics by hand. Eventually the computer graphics will have to be copied.

- Consideration for training distracters.

6. WHAT DID YOU LIKE MOST ABOUT THIS EXERCISE?

- Using the Windows environment - already familiar with it.

- It closely matched training management system in organization but much easier than current methods.

- Phase III - when you were able to execute y our plan and see how it worked.

- OPORD was very easy to modify. Janus capabilities.

- It's a fairly easy system to understand.

- Easier to find tasks. Ability to print what you need. Quick access to training status.

- Being able to see the plan executed as a third party (i.e., not in a turret focusing on a small portion of the battlefield).

- Easy to work with and obtainable.

- The Janus exercise.

- Application to Janus.
- I enjoyed actually planning the mission.
- The Army's idea of expanding.
- The information was known already.
- Janus execution.
- Everything.
- Management of METL task proficiency automated cross walk.
- The actual Janus battle.
- I finally got involved on what to train and how to do it instead of being told.
- I liked being able to conduct a training scenario and observing my strengths and weaknesses in deploying my forces and establishing defend positions.
- Getting hands-on with Janus.
- It was much more user friendly that trying to do it "stubby pencil".
- Almost instantaneous feed back on capabilities and planning execution.
- Execution.
- Watching defensive plan come to fruition.

- It was good to be able to see what areas you need to train for each tasks and how to incorporate those tasks into training.

- The actual Janus time.

- Allows unit to train as you would like to fight and review results with data measurement.

- The actual running of mission to the computer.

- This exercise gave feedback on the results of your planning. This is valuable knowledge before going out to the field to actually do ARTEP missions.

- Small group instruction.

- Evaluates weaknesses and able to work the order for these tasks.

- The planning process, and how it came to play with computer technology.

- The ability on the same system to determine what needs to be trained, put it on a calendar and write an order with overlays to execute. Janus or other system don't need to be a part of this - a unit would benefit just working off a terrain board.

- Actual hand-on to see if we trained the tasks.

- The pre-written documents and METL breakdown.

- Access to knowledge. Ease of use.

- Nothing.

- New and useful.

- Practice doing the training planning process.
- The ability to train faster with more input.
- Simulation demonstration.
- TREDS takes information from many different sources and enters it into a common program. Therefore, once you do an assessment of your proficiency in your METL tasks, TREDS can help you plan and direct your training to address weaknesses and sustain strengths.
- The program was very user friendly.
- Planning at the company level.
- The computer gave you a picture to work with. You could easily try different approaches quickly.
- Paints a better picture of the different scenarios.
- The Janus system is an exciting tool.
- It was different.
- Playing with computers.
- The computer simulation battle.
- Janus training is only 2 hours.
- Having subordinates act as team commander. Relaxed, helpful approach of trainers.

- Planning.

- I was interested to watch/control the battle on Janus.

- Being able to watch the whole battlefield.

- Learning how to better "sequence" the battlefield.

- Force on Force Exercise.

- Realization of the system.

- You can see the results of your plan, this shows you how well you did and increases effort with the planning process.

- Computer movement of the icons and actual visual benefits of seeing plan work.

- The automatic inputs within the TREDS system.

- The thought process going into the assessment.

- The automated/fighting of the battle.

- Watching the actual battle.

- The planning phase and execution of the mission.

- The automation of the updates.

- It gave you a great amount of flexibility, let you learn valuable mistakes with little loss.

- Introduction to Janus.

- The flexibility and user friendliness of the system.

- The hands-on experience utilizing the Janus system.

- Session three.

- The execution of the planning process. To see how all of the hours of prep would turn out.

- Determining weaknesses in my planning process, but also, able to see how planning process can be effective.

- Actually being able to watch, observe and analyze my own battle plan as it happens.

- Actually executing the plan.

- Janus was fun.

- The program has all of the specific tasks - and is pretty easy to use. You don't have to search around through a bunch of manuals.

- Introduction to Janus.

- That METL did drive the training. METL is the focus of everything and unless that is your baseline, you easily get side tracked into dog and pony missions.

- Quickness of execution - able to implement scenario changes.

- The automated assessment process gave easy access to the information and made the storage and recall a useful tool for training. The ability to put an OPORD on the system is also useful.

- Janus.

7. WHAT WOULD YOU CHANGE TO MAKE THIS A BETTER EXERCISE?

- Have the entire program so that all specialty areas can benefit more and understand it in their level.

- Spend more time during familiarization. I would make certain I sent people that knew Microsoft and were familiar with Janus.

- Have leaders plan at their level. This was the first time I had to execute a company level mission I planned.

- Explain in detail during familiarization how all the different aspects of the system tie together.

- Planning and executing the training.

- Allow more time.

- I don't have enough knowledge need to work on it more.

- Can't think of any.

- More detailed explanation of how this can and will make the job better or easier.

- Spend an hour or so to be familiar with Janus in order to execute the plan.

- More time. This is not a one-day affair.
- More in-depth operations on war tactics.
- Allow more freedom to execute developed plan.
- More time on OPORDS.
- Use unit training calendars and events.
- Not so many surveys.
- Give more time to prepare and conduct the exercise.
- Shorter in time duration. More clearly defined goals.
- Nothing in particular.
- Have some info printed and use the program to bring up METL tasks.
- We were using BN level training but trying to modify it to a company plan. This should be, and can be tailored for the individual attempting to use it.
- Interaction with adjacent units on Janus.
- Spend more time in using the computer.
- Involve more military personnel on your staff that have similar experience.
- More prep time.
- Time allowed on system per unit.

- Make sure other soldiers understand what an order is and what it does for the Task force.

- Bring an exercise down to the PLT level, so platoon tasks can be worked on, in order to build up to completing and being fully trained on company tasks.

- Less outside distractions (Location!).

- Nothing.

- More time. More role playing at other terminals.

- Enjoyed it. More time to learn the system.

- Have more time to get better at system.

- Increase database.

- Better orientation to the purpose of the exercise. Better prior planning to allow the "guinea pigs" to prepare.

- The CSS needs a part in the exercise.

- More time with the equipment.

- Make the OPORD readable.

- A complete overview and run through demonstration before starting the exercises. A progress assessment at each Phase of the exercise during which each team leader is required to brief his group's solution to the problem, in the form of an estimate, in order to compare the two methods.

- Better preparation of soldiers to be trained, so that we understand the purpose of the training, the method by which it will be conducted, and the goal of the training. An advance packet would be helpful.

- An introductory period that spelled out the overall goals for the group.

- Prior training in this level of leadership.

- Nothing.

- The ability to put all the tasks on the simulation.

- I would do away with the evaluation of whether the unit is T, P, or U.

- Do more planning (in-depth).

- Concentrate less on order process and more on assessment. Time spent typing order and graphics needs to be reduced (i.e., separate training deficiency)

- Integrate fire support products into OPORD matrix.

- Have one expert take a small group (2 or 3 people) through the entire program - then let us try it out.

- Not to battle the computer, but to battle another team.

- I would allocate some more time for OPORD development - it seems as though the OPORD plans were not really adhered to.

- Allocate more time.

- The random kill or no kill has to be improved. The percentage kills needs to be decreased for infantry trucks.

- Give orders and use computer to put plan in action. After complete check to see if you have met Commander's intent.

- Give it more time.

- More Janus training, so you know what to input.

- Shorter exercises.

- More time allocated to the student to better understand the SATS-

- TREDS and the operation of computer.

- Put symbols library in the Power Point (i.e., mines, wire, routes, etc.)

- Make the system mandatory for all combat officers.

- Identify what echelon you were training before exercise. (I am BN staff - exercise was run at company)

- Extend it.

- Bring in whole leadership teams together, At least at Plt or Co. level.

- Allow more time (conduct planning process twice). Be able to learn from first mistakes and correct second time. OP order b

- Co. level cut down OP Order to Co. level.

- Make the battalion operations order a little less complex.

- Would help if we had longer to get used to the computer and explore the system.

- More controlled selection/prioritization/analysis of tasks (i.e., defend, explore obstacle)

- Give the trainees more of an idea about what will happen before hand. Let them bring their METL or ARTEP results and see how easy it is to turn that into a near, short and long term training plan.

- Let us do both manual and computer exercises to be better able to compare/contrast.

- OPORDs are best written and not edited from a higher headquarters. Paragraphs 2 & 3 require much more effort than just editing a given OPORD.

- Utilize different scenario.

8. ANY OTHER COMMENTS YOUR HAVE TO CONTRIBUTE WOULD BE GREATLY APPRECIATED:

- ♦ I underestimated the computer literacy required of participants. I should have selected participants based on proficiency with computers, rather than strictly by duty position. I should have established preliminary requirements and trained participants to make the program more understandable once they arrived.

- ♦ Good exercise - would like to have more time to conduct exercise - i.e., set up for Janus execution.

- ♦ In the pairing of personnel, i.e. CPT w/LT not LT w/LT

- ♦ This will be a great system once on-line.

- Excellent program.

- Overall, this is an excellent tool to aid a commander in the planning process. If nothing more, when done regularly, it will make the commander more cognizant of the planning process. By having a planning tool, I think as a commander it will be done more, making it easier simply because it will be done more. Practice makes perfect.

- I think this was a good exercise; however, because I was not familiar with operating Janus I did not feel totally comfortable with this exercise.

- One day is not long enough to accurately answer any question asked on this paper. I strongly feel more time should be allotted on the computers.

- For some reason it was very stressful although I don't think it should have been.

- Thank you.

- Automated resource requests and ticklers for deadline i.e., requests, orders. etc.

- I really enjoyed the Janus system and fighting the simulated battle. It makes you think about what needs to be done during battle.

- I believe this may help some leader realize that they need to involve everybody in the training process.

- The system being developed is good for guidance and for checking the block on paper, but one must never forget about the soldiers and NCO's on the ground and their experience. They can offer more input than I think is being accredited to them.

- In assessing the proficiency levels, some areas I annotated N/A because I did not complete the tasks in Janus. Looking back at those tasks, it is possible now to determine how it is that I can apply Janus to accomplish these tasks.

- This has been a first-time experience and I am sure that I do not realize all of the capabilities of Janus or TREDS.

- I do not think I knew enough about these systems to be an accurate representative of my peers.

- The participants must have a working knowledge of Janus and experience with conducting/writing CO/TM missions.

- The class needs to be longer so soldiers get a better understanding of how to plan orders.

- The planning orders phase needs to be longer in order to fully prepare an operations order.

- Time. Sessions should be longer and more in-depth.

- The P.E. at the beginning of the exercise was not really useful. A better experiment would involve maneuver commanders, not NCOs that have no clue about maneuver operations and OPORDS.

- The development of a Janus certification program in conjunction with this system would be great.

- All of this information is used for above my level. I am not familiar with this information nor have I ever used it before. Everything used in this course is officer level. This program would not greatly improve NCO's ability to perform their job and would not benefit enlisted men at all.

- I think more detailed planning would help others understand the system better.

- Longer class time.

- Need a historical matrix for record keeping.

- Perhaps we can plan battles against each other.

- It's a good training tool, best I've seen in 19 years, the symbols library needs to be expanded or improved.

- It takes a long time to input the company data: It can only be done by the unit. It's tedious but necessary.

- The general guidance was not specific enough. It would help to better explain what the overall task was and what it is that you want the teams to do.

- Would like to work both sides (I was on manual side, would like to be automated side if more time was allotted).

- All the trainers helped out when it came to any questions we had.

- Easy to use and understand.

- Good training management system, good luck fielding it.

- Good product - integrated well.

- Very good introduction to training planning process. Most applicable for Company Commander, Bn Staff, and above.

- Most of the problems I experienced were with the MS-Office programs that the CATT ran under. Before users will use all the capabilities of the program they have to be Word (Powerpoint, Excel) proficient. Large parts of the Army

still use WordStar and Framework daily and need to be brought up to speed to really use this. Excellent program!!!

- Company and platoon level tasks are fairly easy to identify. A more useful system needs to incorporate crew level and individual level tasks. This will keep squad leaders and tank Commanders more involved in the training & assessment process.

LIST OF REFERENCES

Anderson, J. (1981). Acquisition of cognitive skills. Office of Naval Research Technical Report 81-1.

Anderson, J. (1987). Methodologies for studying human knowledge. Behavioral and brain sciences, 31, 467-505.

Bayman, P., & Mayer, R. (1984). Instructional manipulation of users' mental models for electronic calculators. International journal of man-machine studies, 20, 189-199.

Bouwens, C., Jones, R., & Pierce, L. (1994). A Distributed Interactive Simulation (DIS) network for evaluating training systems effectiveness. Proceedings of the 16th Interservice/Industry Training Systems and Education Conference. Washington, DC: National Security Industrial Association.

Bovair, S., Kieras, D., & Polson, P. (1990). The acquisition and performance of text-editing skill: A cognitive complexity analysis. Human computer interaction, 5, 1-48.

Brynjolfsson, E. (1993). The productivity paradox of information technology. Communications of the ACM, 36(12), 67-77.

Cañas, J., Bajo, M., & Gonzalvo, P. (1994). Mental models and computer programming. International journal of human-computer studies, 40, 795-811.

Cannon-Bowers, J., Salas, E., Duncan, P., & Halley, E. (1994). Application of multi-media technology to training for knowledge-rich systems. Proceedings of the 16th Interservice/Industry Training Systems and Education Conference. Washington, DC: National Security Industrial Association.

Cannon-Bowers, J., Tannenbaum, S., Salas, E., & Converse, S. (1991). Toward an integration of training theory and technique. Human factors, 33(3), 281-292.

Card, S., Moran, T., & Newell, A. (1983). The psychology of human-computer interaction. Hillsdale, NJ: Lawrence Erlbaum Associates.

Chapman, B., & Allen, R. (1994) Teaching problem solving skills using cognitive simulations in a PC-environment. Journal of interactive instructional development, 24-30.

Conover, W. (1980). Practical nonparametric statistics. New York: Wiley.

Cooper, G., & Harper, R. (1969). The use of pilot rating in the evaluation of aircraft handling capabilities (NASA Report TN-D-5153). Buffalo: Cornell Aeronautical Laboratory.

Crissey, M., Stone, G., Briggs, D., & Mollaghasemi, M. (1994). Training exercise planning: Leveraging data and technologies. Proceedings of the 16th Interservice/Industry Training Systems and Education Conference. Washington, DC: National Security Industrial Association.

Djang, P., Butler, W., Laferriere, R., & Hughes, C. (1993). Training mix model. White Sands Missile Range, NM: Department of the Army.

Drewes, P., & Gonzalez, A. (1994). Automatic performance monitoring and evaluation of computer based training systems. Manuscript submitted for publication.

Eberts, R. (1994). User interface design. Englewood Cliffs, NJ: Prentice-Hall.

Ekstrom, R., French, J., Harman, H., & Dermen, D. (1976). Manual for kit of factor-referenced cognitive tests. Princeton, NJ: Educational Testing Service.

Eliot, L. (1994). Intelligent agents are watching you. AI Expert, 9(8), 9-11.

Estvanik, S. (1994). Artificial intelligence in wargames. AI Expert, 9(5), 22-29.

Fitz-enz, J. (1994). Yes...you can weigh training's value. Training, 31(7), 54-58.

Frankel, F., & Cole, M. (1971). Measures of category clustering in free recall. Psychological bulletin, 76, 39-44.

George, Y., Malcolm, S., & Jeffers, L. (1993). Computer equity for the future. Communications of the ACM, 36(5), 78-84.

Gerjuoy, I., & Spitz, H. (1966). Associative clustering in free recall: Intellectual and development variables. American journal of mental deficiency, 70, 918-927.

Gibson, J., Ivancevich, J., & Donnelly, J. (1994). Organizations: Behavior, structure, processes. Burr Ridge, Illinois: Irwin.

Gluckman, J., & Willis, R. (1994). Intelligent embedded trainers: A next step for computer based training. Proceedings of the 16th Interservice/Industry Training Systems and Education Conference. Washington, DC: National Security Industrial Association.

Gonzalez, A., & Ingraham, L. (1994). Computer-based exercise progression in simulation-based training. IEEE Transactions on Systems, Man, and Cybernetics, 24(6), 863-874.

Gropper, G., & Ross, P. (1987). Instructional design. In R. Craig (Ed.), Training and development handbook, (3rd ed., pp. 195-216). New York: McGraw-Hill.

Hall, J., Dwyer, D., Cannon-Bowers, J., Salas, E., & Volpe, C. (1993). Toward assessing team tactical decision making under stress: The development of a methodology for structuring team training scenarios. Proceedings of the 16th Interservice/Industry Training Systems and Education Conference. Washington, DC: National Security Industrial Association.

Hart, S., & Staveland, L. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. Hancock, & N. Meshkati, (Eds.), Human mental workload (pp. 139-183). North Holland: Elsevier Science Publishers.

Helander, M. (1988). Handbook of human-computer interaction. Amsterdam: Elsevier Science Publishers.

Hollnagel, E., Hoc, J., & Cacciabue, P. (1995). Expertise and technology: Cognition and human-computer cooperation. Hillsdale, NJ: Lawrence Erlbaum.

Inui, M., Myojin, S., & Oba, K. (1993). Simulation Based ICAI with Multimedia. Proceedings of ED-MEDIA 93- World conference on educational multimedia and hypermedia (pp. 262-269). Charlottesville, VA: Association of Advance Computing Education.

Johnson-Laird, P. (1983). Mental models. Cambridge, Massachusetts: Harvard University Press.

Kan, S. (1995). Metrics and models in software quality engineering. Reading, Massachusetts: Addison-Wesley.

Kazarian, J., & Shultz, M. (1994). The IRIS architecture: integrating constructive, live, and virtual simulations. Proceedings of the 16th Interservice/Industry Training Systems and Education Conference. Washington, DC: National Security Industrial Association.

Keiser, T., & Seeler, J. (1987). Games and simulations. In R. Craig (Ed.), Training and development handbook, (3rd ed., pp. 456-469). New York: McGraw-Hill.

Kelleher, G. (1993). Planning for the support of computer users. International journal of man-machine studies, 39, 925-964.

Kellinger, F. (1986). Foundations of behavioral research. New York: Holt, Rhinehart & Wilson, Inc.

Kieras, D. (1988). Towards a practical GOMS model methodology for user interface design. In Helander, M. (Ed.), Handbook of Human-Computer Interaction, (pp. 135-157). Amsterdam: Elsevier Science Publishers.

Kline, P., Blickensderfer, E., Dryer, D., & Bochenek, G. (1995). Development of an expert system for improving the graphic support of decision making. IEMS '95 Proceedings: Annual international conference on industry, engineering and management systems, 192-197. Orlando: University of Central Florida.

Koontz, D. (1994). The door to December. New York: Penguin Group.

Krepinevich, A. (1994). Keeping the pace with the military-technological revolution. Issues in science and technology, Summer, 21-27.

Lindegaard, G. (1987). Who needs what information about computer systems: Some notes on mental models, metaphors and expertise (Branch Paper 126). Clayton, Australia: Telecom Australia Research Laboratories.

Marmaras, N., Lioukas, S. & Liaos, L. (1992). Identifying competences for the design of systems supporting complex decision-making tasks: A managerial planning application. Ergonomics, 35(10), 1221-1241.

Mayer, R. (1989). Models for understanding. Review of educational research, 59(1), 43-64.

McAlindon, P. (1994). The development and evaluation of the Keybowl: A study on an ergonomically designed alphanumberic input device. Unpublished doctoral dissertation, University of Central Florida, Orlando.

McCord, A. (1987). Job training. In R. Craig (Ed.), Training and development handbook, (3rd ed., pp. 363-382). New York: McGraw-Hill.

McGinnis, M. (1994). The system for training emergency personnel (STEP). Unpublished article, United States Military Academy, West Point, New York.

Merrill, M., Li, Z., & Jones, M. (1989). Limitations of first generation instructional design. Educational technology, 30(2), 7-14.

Milton, J., & Arnold, J. (1986). Probability and statistics in the engineering and computing sciences. New York: McGraw-Hill.

Moray, N. (1987). Intelligent aids, mental models, and the theory of machines. International journal of man-machine studies, 27, 619-629.

Nairne, J. (1991). Position uncertainty in long-term memory. Memory and cognition, 19(4), 332-340.

Newell, A., & Simon, H. (1972). Human problem solving. Englewook Cliffs, NJ: Prentice-Hall.

Norman, D. (1983). Some observations on mental models. In Gentner, D. & Stevens, A. (Eds.), Mental models, (pp. 7-14), Hillsdale, NJ: Lawrence Earlbaum Associates.

Noomahan, V. (1993). Training Application of Fossil power plant simulation in Thailand. Simulators X, 25(4), 643-647.

Nygren, T. (1991). Psychometric properties of subjective workload measurement techniques: Implications for their use in the assessment of perceived mental workload. Human factors, 33(1), 17-33.

Parry, S. (1991). Linking training with the business plan. Training and development, 45(5), 32-36.

Parsaye, K., Chignell, M., Khoshafian, S., & Wong, H. (1989). Intelligent databases: Object-oriented, deductive hypermedia technologies. New York: Wiley.

Pemberton, B., Campbell, R., & Ahlers, R. (1992). Automatic scenario generation and control for tactical training systems of the 90's. Unpublished article.

Pemberton, B., Classe, D., Bradley, C., & Wilson, M. (1994). Computer-based exercise preparation and distribution for large scale DIS exercises. Proceedings of the 16th Interservice/Industry Training Systems and Education Conference. Washington, DC: National Security Industrial Association.

Petty, M., & West, P. (1995). Plowshares: Applying a military constructive simulation model to emergency management training. Proceedings of the 1995 Simulation Multiconference (pp. 326-331). San Diego, CA: Society for Computer Simulation.

Pietras, C., & Coury, B. (1994). The development of cognitive models of planning for use in the design of project management systems. International journal of human-computer studies, 40, 5-30.

Roenker, C., Thompson, C., & Brown, S. (1971) Comparison of measures of clustering. Psychological bulletin, 76(1), 45-48.

Roth, E., Mumaw, R., & Pople, H. (1992). Enhancing the training of cognitive skills for improved human reliability: Lessons learned from the cognitive environment simulation project. 1992 IEEE Fifth Conference on Human Factors and Power Plants (pp. 496-498). San Diego: IEEE.

Rouse, W. (1991). Design for success. New York: Wiley.

Rouse, W., Cannon-Bowers, J., & Salas, E. (1992). The role of mental models in team performance in complex systems. IEEE transactions on systems, man, and cybernetics, 22, 1296-1308.

Rouse, W., & Howard, C. (1993). Software tools for supporting planning. Industrial Engineering, 25, 51-53.

Rouse, W., & Morris, N. (1986). On looking into the black box: Prospects and limits in the search for mental models. Psychological bulletin, 100, 349-363.

Salas, E., Dickinson, T., Converse, S., & Tannenbaum, S. (1992). Toward an understanding of team performance and training. In R. Swezey & E. Salas, (Eds.), Teams: Their training and performance. Norwood, NJ: Ablex.

Schank, R. (1994). Tractor factories and research in software design. Communications of the ACM, 37, 19-23.

Schneiderman, B. (1992). Designing the user interface. Reading, Massachusetts: Addison-Wesley.

Schvaneveldt, R., Durso, F., Goldsmith, T., Breen, T., & Cooke, N. (1985). Measuring the structure of expertise. International journal of man-machine studies, 23, 699-728.

Senn, J. (1989). Analysis and design of information systems. New York: McGraw-Hill.

Shedroff, N., Hutto, J., & Fromm, K. (1993). Understanding computers. Alameda, California: SYBEX.

Shih, Y., & Alessi, S. (1994). Mental models and transfer of learning in computer programming. Journal of research on computing in education, 26(2), 154-175.

Shubik, M., & Brewer, G. (1972). Models, simulations, and games- A survey (R-1060-ARPA/RC). Santa Monica, CA: Rand.

Sloman, M. (1994). A handbook for training strategy. Brookfield, Vermont: Gower.

Smith, E. (1987). Measuring results. In R. Craig (Ed.), Training and development handbook, (3rd ed., pp. 32-342). New York: McGraw-Hill.

Spitzer, D. (1993). Training for competence. Educational technology, 33(7), 32-41.

Sproull, N. (1995). Handbook of research methods: A guide for practitioners and students in the social sciences. Metuchen, New Jersey: Scarecrow Press, Inc.

Spurgin, A., Moieni, P., & Orvis, D. (1993). Some thoughts on the use of data for assessing training effectiveness. Proceedings of the 1993 Simulation Multiconference on the International Simulators Conference (pp. 579-584). San Diego, CA: Society for Computer Simulation.

Staggers, N., & Norcio, A. (1993). Mental models: concepts for human-computer interaction research. International journal of man-machine studies, 38, 587-605.

Stanney, K., & Salvendy, G. (1994). Effects of diversity in cognitive restructuring skills on human-computer performance. Ergonomics, 37(4), 595-602.

Stout, R. (1994). Effects of planning on the shared understanding of team member information requirements and efficient communications strategy. Unpublished doctoral dissertation, University of Central Florida, Orlando.

Tannenbaum, S., Cannon-Bowers, J., Salas, E., & Mathieu, J. (1993). Factors that influence training effectiveness: a conceptual model and longitudinal analysis. (Technical Report 93-011). Orlando: Naval Air Warfare Center Training Systems Division.

Tolbert, C., & Bramwell, A. (1992). Perspectives on Training Relative to Standardized Guidance Documents. 1992 IEEE Fifth Conference on Human Factors and Power Plants (pp. 492-495). San Diego, CA: IEEE.

Totterdell, P., Norman, M., & Browne, D. (1987). Levels of adaptivity in interface design. In H. Bullinger, & B. Shackel, (Eds.), Human-computer interaction INTERACT '87 (pp. 715-722). North Holland: Elsevier Science Publishers.

Turnage, J., Houser, T., & Hofmann, D. (1989). An assessment of performance methodologies for collective military training. Orlando: University of Central Florida.

UCF Institute for Simulation and Training. (1993). Value of simulation and training. Unpublished article.

U.S. Department of Defense. (1993). Measures of crew/team training effectiveness. Orlando, FL: Resource Consultants, Inc.

U.S. General Accounting Office. (1993). Army training: Commanders lack guidance and training for effective use of simulations. Gathersburg, Maryland: General Accounting Office.

Wewerinke, P. (1974). Human operator workload for various control situations. 10th Annual Conference on Manual Control. (pp. 167-192). Wright-Patterson AFB, OH: NASA.

White, A. (1994). The impact of cue fidelity on pilot behavior and performance. Proceedings of the 16th Interservice/Industry Training Systems and Education Conference. Washington, DC: National Security Industrial Association.

Williams, K., & Kotnour, T. (1992). Knowledge-acquisition: A review of manual, machine-aided and machine-learning methods. Interim technical report for the Office of Naval Technology under Grant No. N00014-91-J-1500. Blacksburg, Virginia: Virginia Polytechnic Institute and State University.

Williams, K., Reynolds, R, Carolan, T., Anglin, P., & Shrestha, L. (1989). An evaluation of a methodology for cognitively structuring and adaptively sequencing exercise content for embedded training. Technical report TR89-035. University of Central Florida, Orlando: Institute for Simulation and Training.

Wilson, J.R., & Rutherford, A. (1989). Mental models: Theory and application in human factors. Human Factors, 31(6), 617-634.

Zenios, S. (1995). Mathematical programming and modeling. In G. Sabot (Ed.), High performance computing: Problem solving with parallel and vector architectures, (pp. 185-214). Reading, Massachusetts: Addison-Wesley.